LSD-ICD-201
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Interface Control Document between the NASA Goddard Space Flight Center (GSFC) and Department of Interior EROS Data Center (EDC) for Landsat-D

E83-10240

TM-85273

Partially Processed Multispectral Scanner High Density Tape (HDT-AM)

January 4, 1982

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(E83-10240) INTERFACE CONTROL DOCUMENT BETWEEN THE NASA GODDARD SPACE FLIGHT CENTER (GSFC) AND DEPARTMENT OF INTERIOR EROS DATA CENTER (EDC) FOR LANDSAT-D. PARTIALLY PROCESSED MULTISPECTRAL SCANNER HIGH DENSITY G3/43

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GREENBELT, MARYLAND

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LIST OF ILLUSTRATIONS

SECTION 1

SCOPE

1.1 INTRODUCTION

The NASA GSFC Landsat-D Project is developing a Data Management System (DMS) to provide a variety of standard image products from the thematic mapper (TM) and multispectral scanner (MSS) instruments. The major digital image processing functions to be performed by the DMS include: screening imagery for quality, determining cloud cover, applying radiometric corrections, computing sets of geometric corrections corresponding to different map projections, and applying a set of geometric corrections (including resampling the data using either cubic convolution or nearest neighbor techniques and presenting the data in either a space oblique mercator, universal transverse mercator, or polar stereographic projection). One of the outputs from the DMS is partially processed MSS data (radiometric corrections applied and geometric correction matrices for two projections appended) which is recorded on HDT-AM tapes. An HDT-AM is a 28-track or 14-track high density tape.

This specification establishes the requirements for the format of the Landsat-D HDT-AM product. These requirements represent both derived and allocated requirements from the GSFC Specification for the Landsat-D System, GSFC-430-D-100B.

This document is part of the Landsat-D Data Format Control Book. It is one of several appendices to Volume VI, which describe the format of Landsat-D and Landsat-D Prime products.

1.2 PURPOSE

The purpose of this document is to define the format of the HDTs which contain partially processed Landsats-D and D Prime MSS image data. This format is based on and is compatible with the existing format for partially processed Landsat-3 MSS image data HDTs (as delineated in IPF ICD-201).

This document and those cited in Section 2 provide complete specification of the HDT-AM data format and should be followed in utilizing and interpreting the format of these tapes.

1.3 APPLICABILITY

This document applies to all Landsat-D and D Prime partially processed MSS data tapes recorded by the DMS as an output of initial image processing and to all copies of all or parts of these tapes. The formats for the HDTs which contain partially and fully processed Landsat-D Prime TM data are defined in other Data Format Control Book Appendices (HDT-AT in Appendix A, GES 10033; HDT-PT in Appendix B, GES 10034).

SECTION 2

APPLICABLE DOCUMENTS

2.1 GOVERNMENT DOCUMENTS

a. IPF-ICD-201

Interface Control Document between the Image Processing Facility and EDC Digital Image Processing System for Landsat: Partially Processed Multispectral Scanner High Density Tape (HDT-AM/AMC)

2.2 GENERAL ELECTRIC DOCUMENTS

a. SVS 10126

Data Format Control Book, Volume V, Payload

b. SVS 10127

Data Format Control Book, Volume VI, Products

c. GES 10033

Landsat-D Data Format Control Book, Vol. VI, Appendix A (HDT-AT)

d. GES 10034

Landsat-D Data Format Control Book, Vol. VI, Appendix B (HDT-PT)

2.3 OTHER DOCUMENTS

None

SECTION 3

PRODUCT DESCRIPTION

3.1 RECORDED-DATA FORMATS

Partially processed Landsat-D and D Prime MSS data and IRIG-A time code data will be recorded on HDT-AM tapes utilizing Martin-Honeywell Model No. 2879-L high density digital tape recorders. The formatting performed by these recorders (i.e., track assignments, packing density, framing, randomizing, and error correction capability) are specified in the Data Format Control Book, Volume VI: Products (reference paragraph 2.2.b). This appendix does not include any reference to the recorder formatting process.

3.2 TAPE FORMAT

Each HDT-AM tape is arranged in band sequential (BSQ) format. A 14-track HDT-AM can contain up to about 45 scenes, while a 28-track HDT-AM can contain up to about 180 scenes (the absolute maximum capacities are about 25% larger). In order to facilitate transfer of data from 28-track to 14-track tapes, the data on a physical 28-track tape is blocked in "logical" HDT-AM tapes, where each portion of the data known as a "logical" HDT-AM tape will fit onto a single 14-track tape. In actual practice a logical is restricted to a maximum of about 34 scenes due to the hardware configuration used to generate the tapes. There is no restriction on the minimum number of scenes in a logical. However, there will always be only one logical on a physical 14-track HDT-AM tape, and no more than five logicals on a physical 28-track HDT-AM tape. Integral scenes will not be divided between logical tapes.

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Each logical HDT-AM tape contains a tape directory appearing at the beginning, followed by data in the following order for each band of each scene: header, ancillary, annotation, preamble/filler, image, trailer, and more preamble/filler (see Figure 3.2-1). Due to the starting and stopping of HDT-AM tapes which will occassionally be necessary during their generation, data gaps will occur. They will appear only between scenes and usually will occupy only a few inches of tape.

3.2.1 TIME CODE

The HDT-AM contains a longitudinal time track (with time monotonically increasing) on auxillary track number 1 that provides an index to the location of image data on the HDT. The time is recorded in the IRIG-A format (reference paragraph 2.2.a) and has a time resolution of a tenth of a second. The ten-character time code provides hundreds, tens, and units of the day of the year; tens and units of hours; tens and units of minutes; and tens, units, and tenths of seconds. The time code gives the universal time at which the data was recorded on the original HDT-AM tape and is used to correlate image data to sequential position on the HDT (for example on the CHIT). The time code may be discontinuous between data intervals and during data gaps. All other regions of the tape, including preamble/filler, will have time code recorded.

3.2.2 MAJOR FRAME CONVENTIONS

All the information on the tape is organized into major frames. Every major frame is 3232 bytes in length and is divided into eight minor frames of equal size. These values are constant for all parts of all HDT-AM tapes, in no case

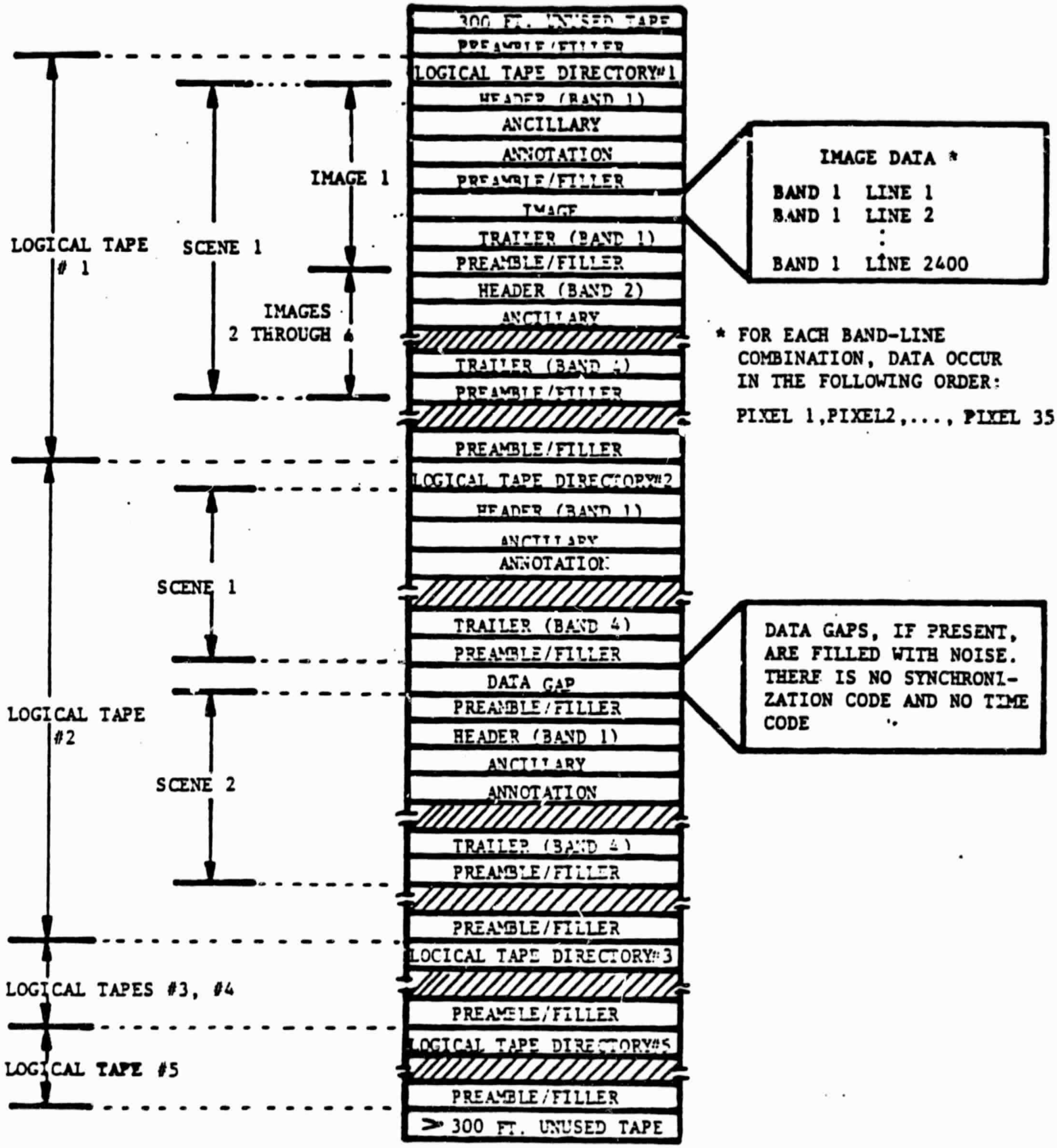

Figure 3.2-1. Layout of an HDT-AM

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will partial major or minor frames occur. The sequence of the major frames on the tape is shown in Figure 3.2-2.

Approximately 3000 major frames of preamble/filler precede each logical tape directory. The logical tape directory is one major frame long. Following each logical tape directory is a set of scenes, each one containing four images.

Each image consists of:

1 major frame of header data

26 major frames of ancillary data

2 major frames of annotation data

158 major frames of preamble/filler

2400 major frames of image data

1 major frame of trailer data.

Between each image in a scene and between the last image in one scene and the first image in the next scene there will be more than 350 major frames of preamble/filler. Figure 3.2-3 shows the spacing and data relationships. In cases where data gaps occur, greater than 350 major frames of preamble/filler will precede the gap and approximately 3000 major frames of preamble/filler will follow the gap.

For all types of major frames except preamble/filler and image data a parameter called the CHECKSUM is computed. The four-byte (32-bit) CHECKSUM is computed on 32-bit segments of data commencing at the boundary between the minor frame type

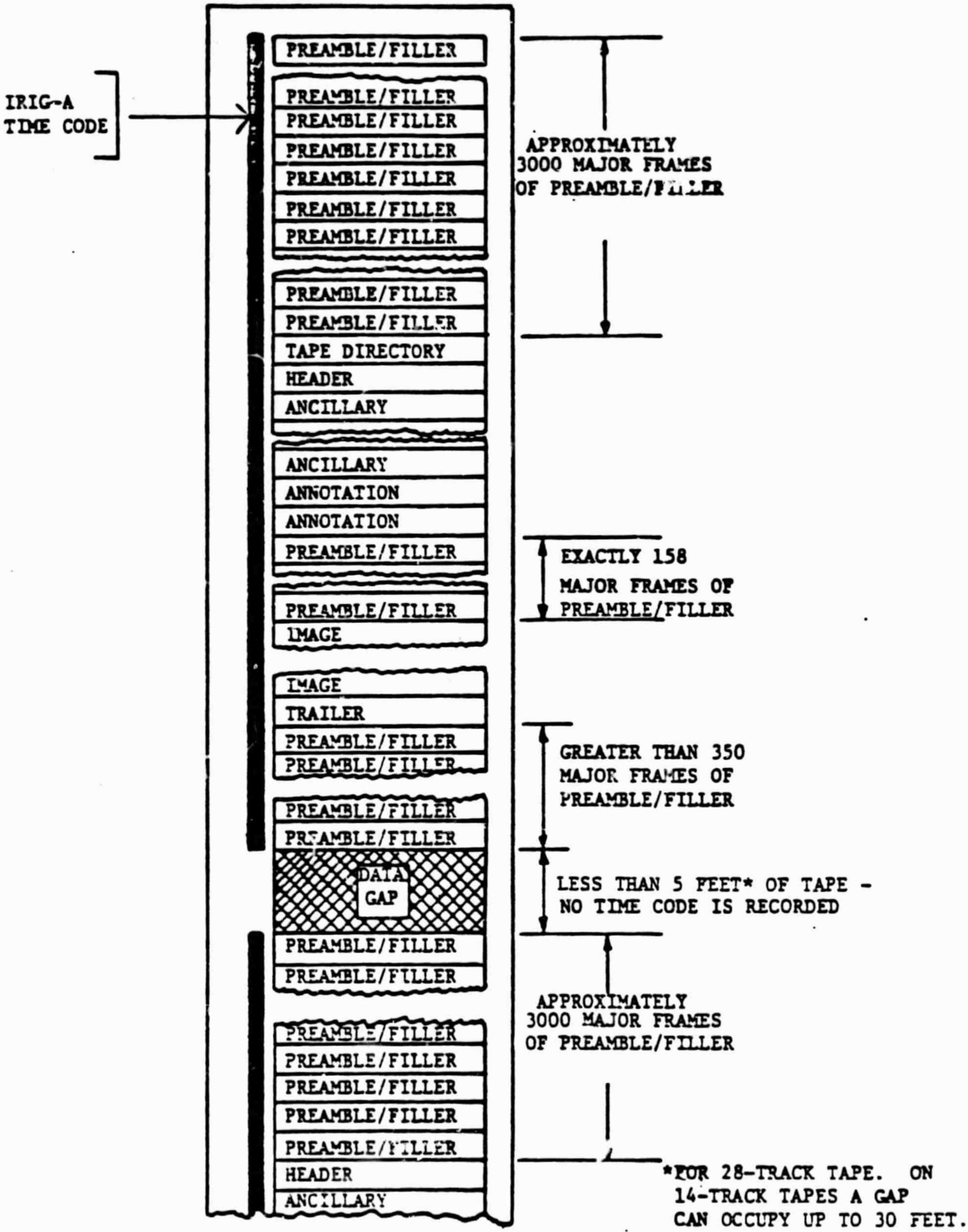

Figure 3.2-2. Symbolic Illustration of the Time Code Track and Other Recorded Data

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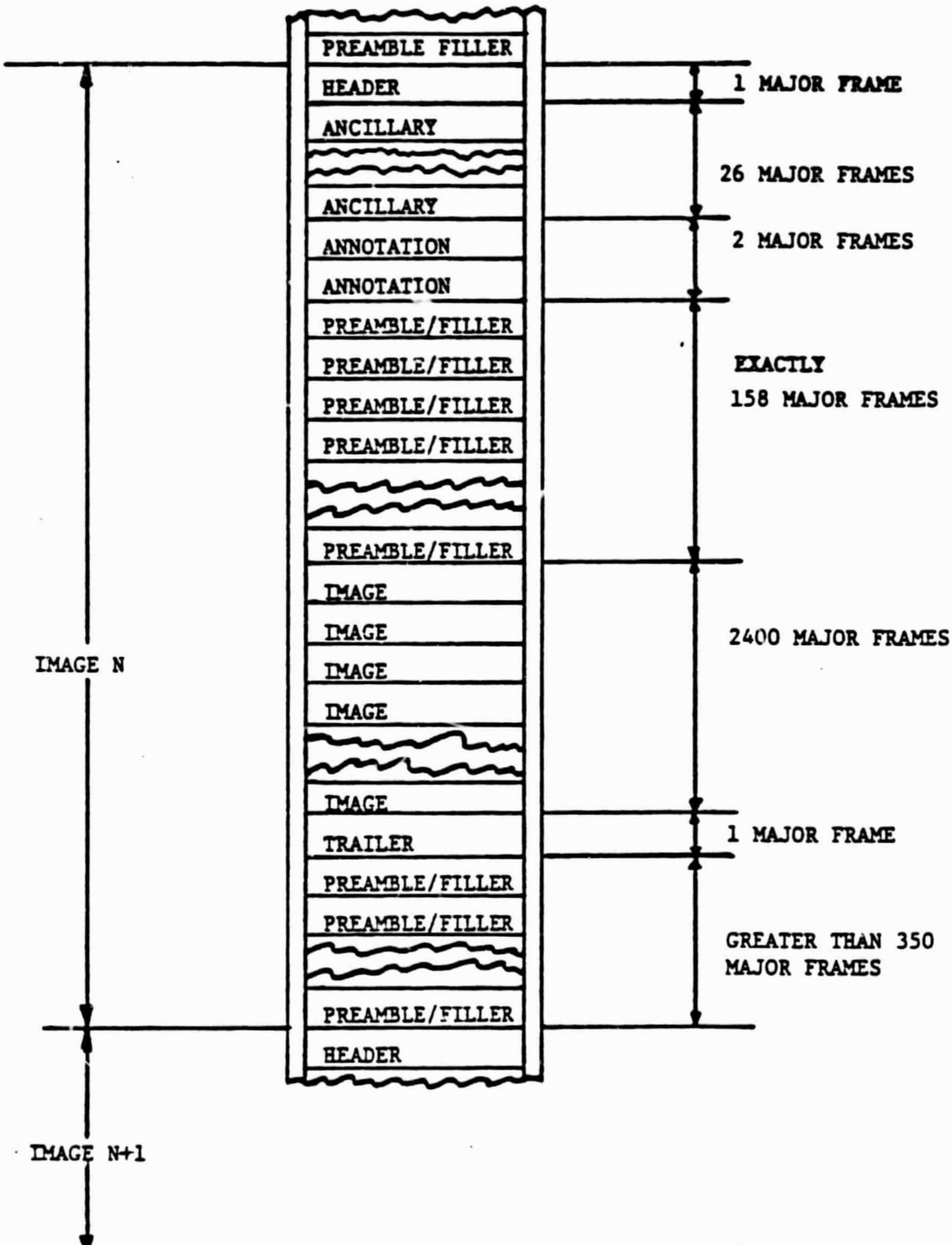


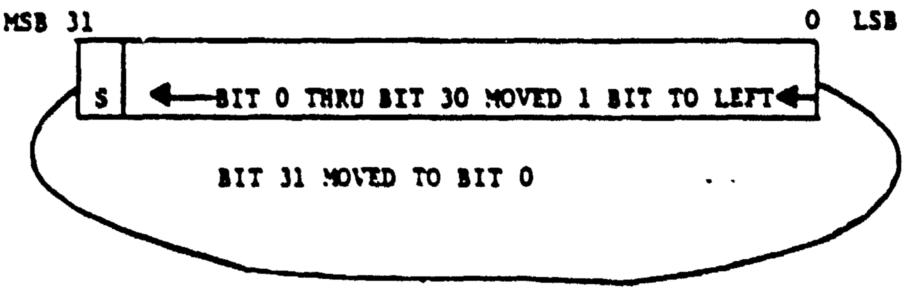
Figure 3.2-3. Representation of Spacing Between MSS Images

code and the alphanumeric data; that is, the six bytes (48 bits) of standard identification information at the beginning of each minor frame are not included in the computation of the CHECKSUM. The CHECKSUM is placed in the major frame following the data fields, the specific location is indicated in the description of each major frame type (paragraph 3.3). The CHECKSUM computation is performed only on the data which precedes it in the major frame (i.e., trailing zero fill is not included).

The CHECKSUM, for a series of data bytes, is computed by performing successive EXCLUSIVE ORs (XOR) between the four bytes of CHECKSUM and a four byte data block, followed by a CHECKSUM bit rotation. The computation is equivalent to the following set of procedural steps:

```
CHECKSUM = 0
DO FOR I = 1 to N  (where 4N is the number of bytes to be checked)
     CHECKSUM = CHECKSUM XOR DATA(I)
     CHECKSUM = ROTATE (CHECKSUM, 1 BIT LEFT)
ENDDO
```

where ROTATE means:



3.2.3 MINOR FRAME CONVENTIONS

Every minor frame is 404 bytes in length for all HDT-AM tapes. The 398-byte data field is preceded by six bytes of standard information: four bytes of frame synchronization, one byte of minor frame count, and one byte of minor frame type code. In addition to the standard information the data field in image type minor frames is preceded by six bytes of scan line identification (SLID). Therefore, image minor frames will contain 12 bytes of standard information and 392 bytes of (pixel) data.

3.2.3.1 Frame Synchronization

A 32-bit pattern, 11 111 010 111 100 110 011 010 000 000 000 (FAF3 3400 HEX), repeated at the beginning of every minor frame, provides frame synchronization. The most significant bit occurs first and is the left-most bit of the pattern. In figures depicting major frames this pattern is referred to as the SYNC pattern.

3.2.3.2 Minor Frame Count

Within each major frame the binary minor frame count starts at zero and continues in sequence until its value equals seven. Under no circumstance is the minor frame count reset to zero or any other number until the end of the major frame.

3.2.3.3 Minor Frame Type Code (MFTC)

The minor frame type code is a number that defines the type of data within a minor frame. Each minor frame contains one of seven types of information. The

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MFTC byte consists of two identical three-bit data words ($W_1 = W_2$), and two identical one-bit parity words ($P_1 = P_2$) which provide single-bit-error-correcting capabilities. The codes used are:

DATA TYPE	HEXADECIMAL VALUE	OCTAL VALUE	BINARY REPRESENTATION
Preamble/Filler	C0	300	1 1 0 0 0 0 0 0
Tape Directory	09	011	0 0 0 0 1 0 0 1
Header	12	022	0 0 0 1 0 0 1 0
Annotation	DB	333	1 1 0 1 1 0 1 1
Ancillary	24	044	0 0 1 0 0 1 0 0
Image	ED	355	1 1 1 0 1 1 0 1
Trailer	F6	366	1 1 1 1 0 1 1 0
			P_1 P_2 W_1 W_2

Where:

W_1 = three-bit MFTC word number 1

W_2 = three-bit MFTC word number 2

P_1 = parity bit for W_1

P_2 = parity bit for W_2

3.2.3.4 Data Representations

In addition to binary coded data and information in standard ASCII format, four special formats, detailed in the following paragraphs, are utilized to represent fixed and floating point numbers. In all cases the order of the bytes is as shown, that is, no byte-swapping is performed.

3.2.3.4.1 Fixed Point Binary Format (FP)

This format is used in ancillary major frames 1 and 2 and in the header and

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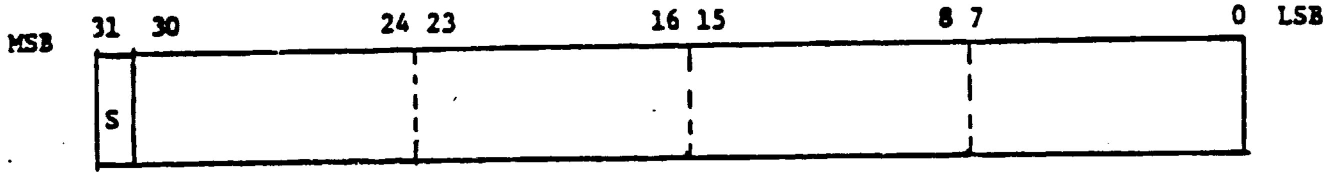
trailer major frame. A number is represented in four bytes, as follows:



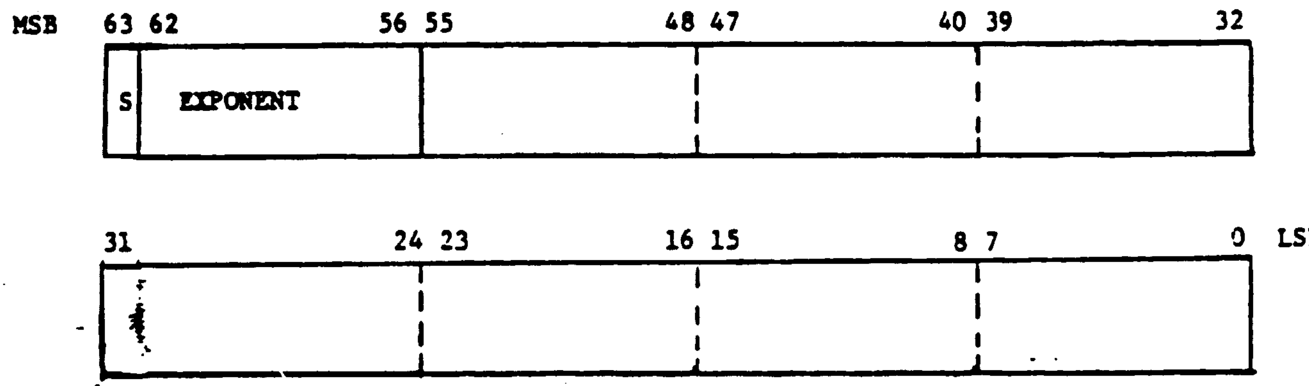
FIXED POINT BINARY FORMAT (FP)

BIT 31 → S(SIGN)=0(+), 1(-)
BITS 30:0 → MAGNITUDE

NOTE: Negative numbers (sign bit = 1) are represented in two's complement form.

3.2.3.4.2 <u>Floating Point Binary Format (FL)</u>

This format is used in ancillary major frames 1 and 2 and in the trailer major frame. This format is also commonly called the long precision (double word) format. A number is represented in eight bytes, as follows:



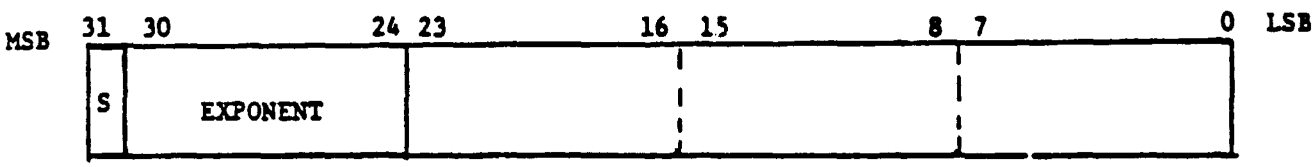
FLOATING POINT BINARY FORMAT (FL)

BIT 63 → S(SIGN)=0(+), 1(-)
BITS 62:56 → EXPONENT, RANGE OF-64 THROUGH +63. TREATED AS EXCESS 64.
BITS 55:0 → FRACTION MAGNITUDE, 14 HEXIDECIMAL DIGITS. THE VALUE IS FOUND BY MULTIPLYING THE FRACTIONAL PART BY THE POWER OF 16.

NOTE: The FL format does not utilize two's complement notation.

3.2.3.4.3 Single Precision Floating Point Binary Format (FLS)

This format is used in ancillary major frames 1 and 2 and in the header major frame. A number is represented in four bytes, as follows:



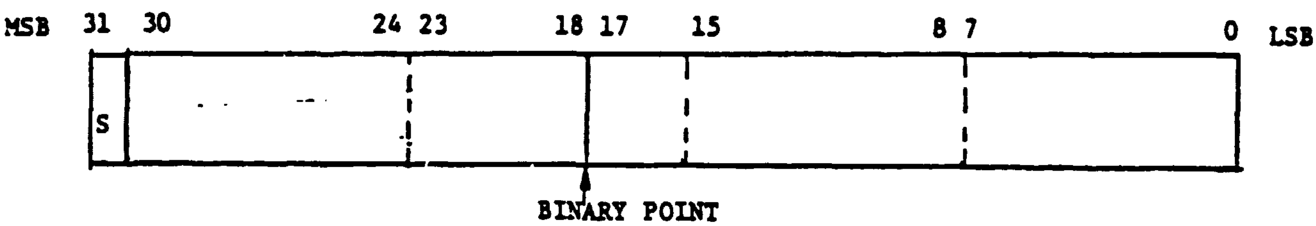
SINGLE PRECISION FLOATING POINT BINARY FORMAT (FLS)

BIT 31 ⟶ S(SIGN)=0(+), 1(-)
BITS 30:24 ⟶ EXPONENT, RANGE OF -64 THROUGH +63. TREATED AS EXCESS 64.
BITS 23:0 ⟶ FRACTION MAGNITUDE, 6 HEXIDECIMAL DIGITS. THE VALUE IS FOUND BY MULTIPLYING THE FRACTIONAL PART BY THE POWER OF 16.

NOTE: The FLS format does not utilize two's complement notation.

3.2.3.4.4 Fixed Point Format for HRS Grid Pixels, VRS Line Coordinates, or Grid Fill Counts

This format is used in ancillary major frames 3 through 18. A number is represented in four bytes, as follows:



GRID PIXEL, GRID LINE COORDINATE, OR GRID FILL COUNT FORMAT

BIT 31 ⟶ (SIGN)=0(+), 1(-)
BITS 30:18 ⟶ INTEGER MAGNITUDE
BITS 17:0 ⟶ FRACTION MAGNITUDE

NOTE: Negative numbers (sign bit = 1) are represented in two's complement form (of the integer and fraction field together).

3.3 MAJOR FRAME TYPES

3.3.1 PREAMBLE/FILLER

Preamble/filler is placed on a tape primarily to ensure the proper operation of the recorder in the playback mode and to separate each image. Each minor frame of preamble/filler begins with the six bytes of standard identification data (sync pattern, minor frame count, and minor frame type code) and is completed

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with the preamble/filler pattern, which consists of alternating 1's and 0's (101010101010...). This pattern is repeated until the complete major frame is filled, as shown in Figure 3.3-1.

3.3.2 TAPE DIRECTORY DATA

The logical tape directory consists of one major frame containing an alphanumeric description of the "logical" tape. The description contains information such as the logical HDT identification number, date of generation, etc. Each minor frame of the tape directory begins with the six bytes of standard identification information, followed by the tape description and zero fill. A major frame of tape directory is shown in Figure 3.3-2. Table 3.3-1 lists specific items that are found in the tape directory. A tape directory appears at the beginning of the tape; on a 28-track high density tape additional tape directories may appear, splitting the data into multiple "logical" HDT-AM tapes. Each "logical" HDT-AM tape fits onto a single 14-track high density tape. Scenes are not divided between logical tapes.

The correlation between the external tape label and the logical tape identifier is as follows for various circumstances:

a. For an original 28-track HDT the tape label is the same as the identifier of the first logical on that physical tape.

b. For 14-track HDTs (which are all copied from 28-track HDTs) the tape label is the same as the the logical identifier.

c. A whole tape copy will have a tape label which is identical to the tape label of its parent except it will contain a "C" to indicate that it is a copy.

3232 bits

48 bits | (3184 Bits) (398 Bytes)

Minor Frame	32 bits	8 bits	8 bits	(3184 Bits) (398 Bytes)
0	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Binary Field of 10101010...10101010101010
1	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Binary Field of 10101010...10101010101010
2	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Binary Field of 10101010...10101010101010
3	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Binary Field of 10101010...10101010101010
4	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Binary Field of 10101010...10101010101010
5	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Binary Field of 10101010...10101010101010
6	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Binary Field of 10101010...10101010101010
7	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Binary Field of 10101010...10101010101010

Figure 3.3-1. One Major Frame of Preamble/Filler

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3232 bits: 48 bits (32 bits, 8 bits, 8 bits) + (3184 bits) (398 bytes)

Minor Frame	SYNC Pattern (32 bits)	Minor Frame Count (8 bits)	Minor Frame Type Code (8 bits)	(3184 bits) (398 bytes)		
0	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	40 Bytes of Tape Directory Data	4 Bytes of CHECKSUM	354 Bytes of Zero Fill
				See Table 3.3-1		
1	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Minor Frame 0 Repeated		
2	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Minor Frame 0 Repeated		
3	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Minor Frame 0 Repeated		
4	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Minor Frame 0 Repeated		
5	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Minor Frame 0 Repeated		
6	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Minor Frame 0 Repeated		
7	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Minor Frame 0 Repeated		

Figure 3.3-2. One Major Frame of Tape Directory

Table 3.3-1. Logical Tape Directory Data Elements

A. Tape Identification

BYTES	DATA		DESCRIPTION
1 - 2	L	N	Logical Tape Identification - contains 20 ASCII bytes of tape identification:
3 - 4	M	H	"L" = Landsat mission designator N = Mission Number (4 for Landsat-D, 5 for Landsat-D', 0 for these logicals containing both Landsat-D and D Prime) "M" = MSS sensor type "HA" = Tape type designator for HDT-A YY = Last two digits of year (00-99) DDD = Day of year (001-366) on which original HDT-AM tape was generated XX = Unique identifier (1-99) for each logical generated on day DDD b̸ = blank
5 - 6	A	Y	
7 - 8	Y	D	
9 - 10	D	D	
11 - 12	X	X	
13 - 14	b̸	b̸	
15 - 16	b̸	b̸	
17 - 18	b̸	b̸	
19 - 20	b̸	b̸	
21 - 22	Day	Mon	Date of Tape Generation - contains the date in binary, where Yr is the last two digits of the year. (For a copy tape this contains the date the original was generated.)
23	Yr		
24		XXX	Source of HDT-AM production - hardware string used to generate tape: $001)_8$ = MIPS #1 $002)_8$ = MIPS #2 $003)_8$ = MIPS #3
25 - 40	X	X	Software Version Number - 16 ASCII bytes
41 - 44	XXX XXX XXX XXX		CHECKSUM value for bytes 1-40 of Tape Directory
45 - 398	000	000	Zero Fill (not used)

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The part of the tape directory which contains the generation date will not be changed during the copy process, it will always contain the date on which the original was generated.

3.3.3 BAND HEADER DATA

The band header contains information associated with a particular band of image data. This information describes the conditions under which the image was recorded and the formats used. Figure 3.3-3 illustrates a major frame of header data.

Header data are subdivided into five groups:

a. Image identification

b. Spacecraft description

c. Time of exposure and WRS designator

d. Data identification and characteristics

e. Special purpose fields.

The data elements of these groups are listed in Table 3.3-2. Unless otherwise noted, all alphanumeric data in the header is ASCII encoded and all numerical "counts" are encoded in binary.

3.3.4 ANCILLARY DATA

The ancillary data provides geometric correction information which enables partially processed imagery to be fully processed at a later date, i.e., to go

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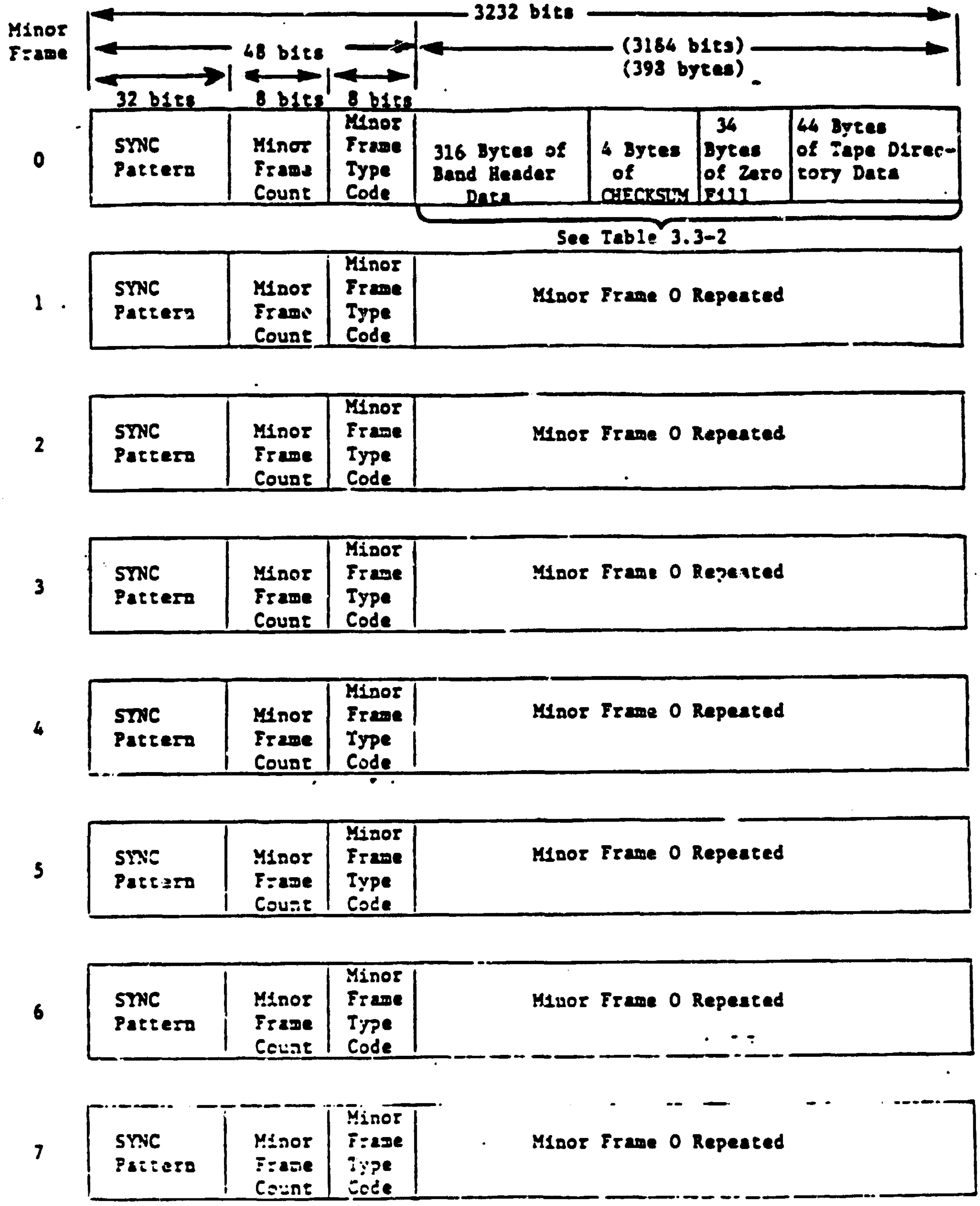

Figure 3.3-3. One Major Frame of Header

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Table 3.3-2. Header Data Elements

A. Image Identification

BYTES	DATA		DESCRIPTION
1 - 2	b̸	N	Image Identification (ASCII) - unique image identifier of the form: b̸NDDDDHHMMSB where N = Landsat mission number: 4 or 5 DDDD = Days after launch at time of observation HH = Hour at time of observation MM = Minute at time of observation S = Tens of seconds at time of observation, where time of observation is universal time (GMT) B = Band Identification Code: 1, 2, 3, or 4 for MSS.
3 - 4	D	D	
5 - 6	D	D	
7 - 8	H	H	
9 - 10	M	M	
11 - 12	S	B	
13 - 14	b̸	M	WRS Designator (ASCII) - unique terrestrial image identifier of the form: MPPPRRR where M = A (for ascending node) or D (for descending node) PPP = WRS path number RRR = WRS row number
15 - 16	P	P	
17 - 18	P	R	
19 - 20	R	R	
21 - 22	Day	Mon	Date of Tape Generation - contains the date in binary, where Yr is the last two digits of the year. (For a copy tape this contains the date the original was generated.)
23	Yr		
24		000	Zero Fill (not used)
25 - 30	000	000	

B. Spacecraft Description

BYTES	DATA		DESCRIPTION
31 - 32	M	S	Sensor Identification (ASCII)
33 - 34	S	b̸	
35 - 38	b̸	b̸	
39 - 40	000	N	Mission Number (binary) - $4)_{10}$ for Landsat-D and $5)_{10}$ for Landsat-D Prime

Table 3.3-2. Header Data Elements (cont'd)

B. Spacecraft Description (cont'd)

BYTES	DATA		DESCRIPTION
41 - 42	XXX XXX		Orbit Number (binary)-spacecraft orbit during which the image was acquired
43 - 44	1: 9:	See Table 3.3-3	Active Detector Status - contains detector status for the 24 MSS detectors. There is 1 bit per detector starting with detector 1 status in the left-most bit, with a 1 indicating an active status. If a sensor is disabled or inactive during the data acquisition pass, this status will be 0.
45 - 46	17: 000		
47 - 48	000 000		
49 - 50	000 000		
51	XXX		Active Detector Count (binary)-the number of active detectors
52 - 53	XXX XXX		Nominal number of image data pixels per scan line in geometrically uncorrected image (binary).
54 - 56	000 000 000		Zero Fill (not used)

C. Time of Exposure/WRS Designator (ASCII unless otherwise specified)

BYTES	DATA	DESCRIPTION
57 - 66	000 000	Zero Fill (not used)
		World Reference System (WRS) Designator in Fully Processed Image (binary):
67 - 68	002 724	Scan line containing WRS center, always 1492)$_{10}$
69 - 70	000 000	Pixel number of WRS center, always 0 (not used, reserved for later entry during geometric correction process)
71 - 72	Yr Yr	Universal Time (GMT) of Picture Center:
73 - 74	D D	Last 2 digits of year (00-99)
75 - 76	D Hr	Day of year (3 digits: 001-366)
77 - 78	Hr Min	Hour (2 digits: 00-23)
79 - 80	Min Sec	Minutes (2 digits: 00-59)
81 - 82	Sec ms	Seconds (2 digits: 00-59) and
83 - 84	ms ms	Milliseconds (3 digits: 000-999)
85 - 86	b̸ b̸	

Table 3.3-2. Header Data Elements (cont'd)

D. Data Identification and Characteristics

BYTES	DATA	DESCRIPTION
87 - 88	006 240	Number of Bits per Minor Frame. (binary) This will always be 3232)$_{10}$
89 - 90	000 010	Number of Minor Frames Per Major Frame. (binary) This will always be 8)$_{10}$
91 - 92	000 260	Number of Bytes of data in Section E, Special Purpose Fields: (binary) always 176)$_{10}$ (includes CHECKSUM)
	Annotation Data Characteristics (binary)	
93	016	Number of Minor Frames which contain Annotation Data, always 14)$_{10}$
94	002	Number of Major Frames of Annotation Data, always 2)$_{10}$
95 - 96	003 252	Total number of Bytes of Annotation Data, always 1706)$_{10}$
	Ancillary Data Characteristics	
97	320	Number of Minor Frames of Ancillary Data, always 208)$_{10}$
98	032	Number of Major Frames of Ancillary Data, always 26)$_{10}$
99 - 100	000 000	Zero Fill (not used)
101	000	Geometric Corrections Applied, always 000)$_8$ = No
102	377	Geometric Correction Data Present, always 377)$_8$ = Yes
103	XXX	Radiometric Correction Applied, 377)$_8$ = Yes; 000)$_8$ = No
104	XXX	Radiometric Correction Data Present, 377)$_8$ = Yes; 000)$_8$ = No
	Image Data Characteristics (binary unless otherwise specified)	
105 - 106	004 540	Number of Major Frames of Image Data, always 2400)$_{10}$
107 - 108	000 000	Zero Fill (not used)
109 - 110	000 044	Number of 7-Bit Calibration/Quality Data Words Per Scan Line, always 36)$_{10}$

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Table 3.3-2. Header Data Elements (cont'd)

D. Data Identification and Characteristics (cont'd)

BYTES	DATA	DESCRIPTION
111	000	Image Data Format - always 000)$_8$ for geometrically uncorrected rectangular image.
112	000	Zero Fill (not used)
113	000	
114	000	Interleaving Type Indicator, always 0)$_8$ for BSQ
115	000	Line Interleaving Count, always 0)$_8$ for non-interleaved data
116	007	Number of Bits Per Pixel, always 7)$_{10}$
117	300	Resampling Applied, always 300)$_8$ = None
118	XXX	Map Projection Selected (corresponds to first map projection in ancillary and annotation data sections, second map projection is always Space Oblique Mercator): 011)$_8$ = Universal Transverse Mercator (UTM) 022)$_8$ = Polar Stereographic (PS)
119 - 120	000 000	WRS Offset from Fully Processed Image Center, always 0 (not used, reserved for later entry during geometric correction process).
121 - 122	000 000	Zero Fill (not used)
123	000	Image Data Justification, always 0 indicating left justification. (Linear data, 6-bit, has zero in MSB.)

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Table 3.3-2. Header Data Elements (cont'd)

D. Data Identification and Characterisitics (cont'd)

BYTES	DATA	DESCRIPTION
124	000	Location of Most Significant Bit, always 0, indicating left
125 - 126	006734	Number of Pixels Per Scan Line, in both partially processed and fully processed image data, always $3548)_{10}$ including fill pixels.
127 - 128	000 000	Zero Fill (not used)
129	004	Number of Images per Scene, always $4)_{10}$
130	X	MSS band number in ASCII: 1, 2, 3 or 4
131 - 144	000 000	Zero Fill (not used)

E. Special Purpose Fields

BYTES	DATA	DESCRIPTION
145	XXX	Orbital Direction - $000)_8$ = Descending Node $377)_8$ = Ascending Node
146	X	Overall Band Quality Indicator (ASCII) See table 3.3-4.
147	XXX	Radiometric Calibration Method $000)_8$ = No corrections applied $011)_8$ = Histogram method $033)_8$ = Cal wedge values only (no histograms) $055)_8$ = Non-standard corrections applied
148	000	Zero Fill (not used)
149 - 152	XXX XXX XXX XXX	Relative Calibration Accuracy, maximum difference between detector means for the image, FLS format
153 - 154	000 000	Zero Fill (not used)
155	000	
156	XXX	Sensor Mode $007)_8$ = low gain linear $070)_8$ = low gain compressed $077)_8$ = high gain linear $300)_8$ = high gain compressed
157-158	XXX XXX	Number of ephemeris data points in the telemetry interval. (binary)
159-160	XXX XXX	Number of rejected ephemeris data points in the telemetry interval (binary)
161-162	XXX XXX	Number of attitude data points in the telemetry interval (binary)

Table 3.3-2. Header Data Elements (cont'd)

E. Special Purpose Fields (cont'd)

Byte	Format	Description
163-164	XXX XXX	Number of rejected attitude data points in the telemetry interval (binary)
		Input Data Quality Indicators Assessment of the data utilized in generating the partially processed image. Telemetry:
165 - 168	XXX XXX XXX XXX	Length of telemetry interval in seconds, FLS format
169	000	ZERO FILL
170	000	ZERO FILL
171 - 182	XXX XXX XXX XXX	Accuracy of ephemeris fit, RMS difference in meters between fit and data points. 3 values in FLS format, one each for altitude, along-track position, and across-track position.
183	000	ZERO FILL
184	000	ZERO FILL
185 - 196	XXX XXX XXX XXX	Accuracy of attitude fit, RSS angular increment between successive data points. 3 values in FLS format, one each for pitch, roll and yaw.
		Control Points: Overall Band qualities (ASCII) of scene from which control points were extracted (reference image) (See byte 146 in header for definition)
197	X	Band 1
198	X	Band 2
199	X	Band 3
200	X	Band 4
201	XXX	Number of geodetic points used in reference image control point extraction process (binary)
202	XXX	Average* previous registration success. Percent previous successful registrations of control points (binary)
203- 204	000 000	Zero fill (not used)

*Average of CPs used in calculations for present scene

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Table 3.3-2. Header Data Elements (cont'd)

E. Special Purpose Fields (cont'd)

205 - 208	XXX XXX / XXX XXX	Average* initial autocorrelation peak value, FLS format
209 - 216	XXX XXX / XXX XXX	Ninety percent error ellipse of control points in reference image. Two values, along-track and across-track, in FLS format (in meters)
217 - 220	XXX XXX / XXX XXX	Correlation Factor Average* of control point correlation peak values, in FLS format.
221 - 224	XXX XXX / XXX XXX	Average* control point suitability measure Average of autocorrelation surface peak curvatures, in FLS format.
225	XXX	Nominal Overlap Mark Pixel Offset in fully processed image data (binary), see Figure 3.3-6.
226	X	Quality assessment of appended geometric modeling data. (ASCII) See Table 3.3-5.
227 - 230	000 000 / 000 000	Zero fill (not used)
231	X	Data Source (ASCII) W - TDRSS/White Sands, S - Simulator U - Alaska, T - Transportable Ground Station, N - NTTF, F - Foreign, G - Goldstone
232	000	Reserved for future use as a processing anomaly indicator.
233 - 236	000 000 / 000 000	Zero fill
237 - 238	XXX XXX	Uncorrectable ECC count for the scene (binary) Total count accumulated during input of data in HDT-AM creation process.
239 - 240	XXX XXX	Indication of bit error rate for the scene (binary) Number of sweeps which had at least one minor frame sync loss (more than three consecutive minor frame sync words containing at least one bit error). There are 6 bits per sync word. Including calibration data there are about 2100 sync words per sweep.

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Table 3.3.-2. Header Data Elements (cont'd)

E. Special Purpose Fields (cont'd)

BYTES	DATA	DESCRIPTION
241 - 242	000 000	Zero Fill (not used)
243	XXX	Use of Nominal Calibration Wedge Values (C $000)_8$= Not used $007)_8$= Used for comparison only $070)_8$= Used to replace CWVs outside won but not used in radiometric calibration $077)_8$= Used to replace CWVs outside winc and used in radiometric calibrati
244	XXX	Window Size (binary) The neighborhood of the nominal values t which the actual CWVs are compared
245 - 280	XXX XXX	Nominal Calibration Wedge Values 36 one-byte binary values (six values fo each of six detectors). Always 6 bit numbers, since the comparison is with CWVs before decompression.
		Calibration Wedge Quality Total number of times CWV did not fall in Nominal ± Window neighborhood. One, one byte value for each sample and sensor. Since samples are acquired on alternate sweeps, the maximum value for each sample and sensor is 200.
281		Sensor 1 Sample 1
282		Sensor 1 Sample 2
283		Sensor 1 Sample 3
284		Sensor 1 Sample 4
285		Sensor 1 Sample 5
286		Sensor 1 Sample 6
287		Sensor 2 Sample 1
288		Sensor 2 Sample 2
289		Sensor 2 Sample 3
290		Sensor 2 Sample 4

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Table 3.2-3. Header Data Elements (cont'd)

E. Special Purpose Fields (cont'd)

BYTES	DATA	DESCRIPTION
291		Sensor 2 Sample 5
292		Sensor 2 Sample 6
293		Sensor 3 Sample 1
294		Sensor 3 Sample 2
295		Sensor 3 Sample 3
296		Sensor 3 Sample 4
297		Sensor 3 Sample 5
298		Sensor 3 Sample 6
299		Sensor 4 Sample 1
300		Sensor 4 Sample 2
301		Sensor 4 Sample 3
302		Sensor 4 Sample 4
303		Sensor 4 Sample 5
304		Sensor 4 Sample 6
305		Sensor 5 Sample 1
306		Sensor 5 Sample 2
307		Sensor 5 Sample 3
308		Sensor 5 Sample 4
309		Sensor 5 Sample 5
310		Sensor 5 Sample 6
311		Sensor 6 Sample 1
312		Sensor 6 Sample 2
313		Sensor 6 Sample 3
314		Sensor 6 Sample 4
315		Sensor 6 Sample 5
316		Sensor 6 Sample 6
317 - 320		CHECKSUM Value for Header Data, includes only the data in bytes 1 - 316
321 - 354		Zero Fill (not used)
355 - 398	See Table 3.3.1	Data bytes of the tape directory are repeated here for special processing purposes. (The tape directory CHECKSUM value includes only the data in bytes 355 - 394).

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Table 3.3-3. Active Detector Byte Assignment

BIT POSITION BYTES 43-45 IN HEADER DATA	INTRA-BAND DETECTOR ASSIGNMENT	
1	Band 1	Detector 1
2	Band 1	Detector 2
3	Band 1	Detector 3
4	Band 1	Detector 4
5	Band 1	Detector 5
6	Band 1	Detector 6
7	Band 2	Detector 1
8	Band 2	Detector 2
9	Band 2	Detector 3
10	Band 2	Detector 4
11	Band 2	Detector 5
12	Band 2	Detector 6
13	Band 3	Detector 1
14	Band 3	Detector 2
15	Band 3	Detector 3
16	Band 3	Detector 4
17	Band 3	Detector 5
18	Band 3	Detector 6
19	Band 4	Detector 1
20	Band 4	Detector 2
21	Band 4	Detector 3
22	Band 4	Detector 4
23	Band 4	Detector 5
24	Band 4	Detector 6

Table 3.3-4. Overall Band Quality Codes
(byte 146 in Header Data Section)

The assessment of the overall quality of a band of imagery is based on the combined geometric, radiometric, and image data quality. The codes are calculated as follows

Code	Relative Quality	Geometric* Correction Quality Code	Radiometric* Correction Quality Code	Image* Data Quality Code
C	Best	E	E	E
B		E	E	G
A		E	G	E
9		G	E	E
8		E	G	G
7		G	E	G
6		G	G	E
5		G	G	G
4		A	E	E
3		A	E	G
2		A	G	E
1		A	G	G
0		A	E or G orA	A
0	Acceptable	A	A	E or G or A

* E=EXCELLENT
G=GOOD
A=ACCEPTABLE

The Geometric Correction Quality Code is defined in Table 3.3-5.
The Radiometric Correction Quality Code is defined as follows:

$$0 \leq RCA \leq 1.0 \Rightarrow E$$

$$1.0 < RCA \leq 2.0 \Rightarrow G$$

$$2.0 < RCA \Rightarrow A$$

Where RCA is the Relative Calibration accuracy as defined in bytes 149 through 152 of the header.
The Image quality Code is defined as follows

$$0 \leq DQI \leq 1.5 \Rightarrow E$$

$$1.5 < DQI \leq 4.5 \Rightarrow G$$

$$4.5 < DQI \Rightarrow A$$

Where DQI is defined as DQI=Major frame synch losses + Minor Frame synch losses/20 + Unrecoverable ECC count errors/20

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Table 3.3-5. Overall Geometric Assessment Quality Codes (Byte 226 in Header Data Section)

The assessment of the overall quality of the geometric modeling process is based upon the number and distribution of control points used. The code actually represents the number of parameters modeled in the Geometric Correction Data processing. The code can take on the following values:

Code	Parameters Modeled	Overall Band Quality Code
0	none, correction is SCD only	A
2	Along track, across track (control points used to calculate translation errors)	G
4	Along track, across track, yaw, altitude	E
6	Along track, across track, yaw, altitude, along track rate, across track rate	E

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from a geometrically uncorrected array of pixels to a geometrically corrected array of pixels. A total of 26 major frames of ancillary data constitute the ancillary data section. A generalized major frame of ancillary data is illustrated in Figure 3.3-4. The ancillary major frames contain information in the following order:

a. Two major frames of geometric modeling data

b. Eight major frames of UTM or PS (depending on image latitude) map projection dependent data

c. Eight major frames of SOM map projection dependent data, in the same format as the previous eight major frames

d. Eight major frames of zero fill.

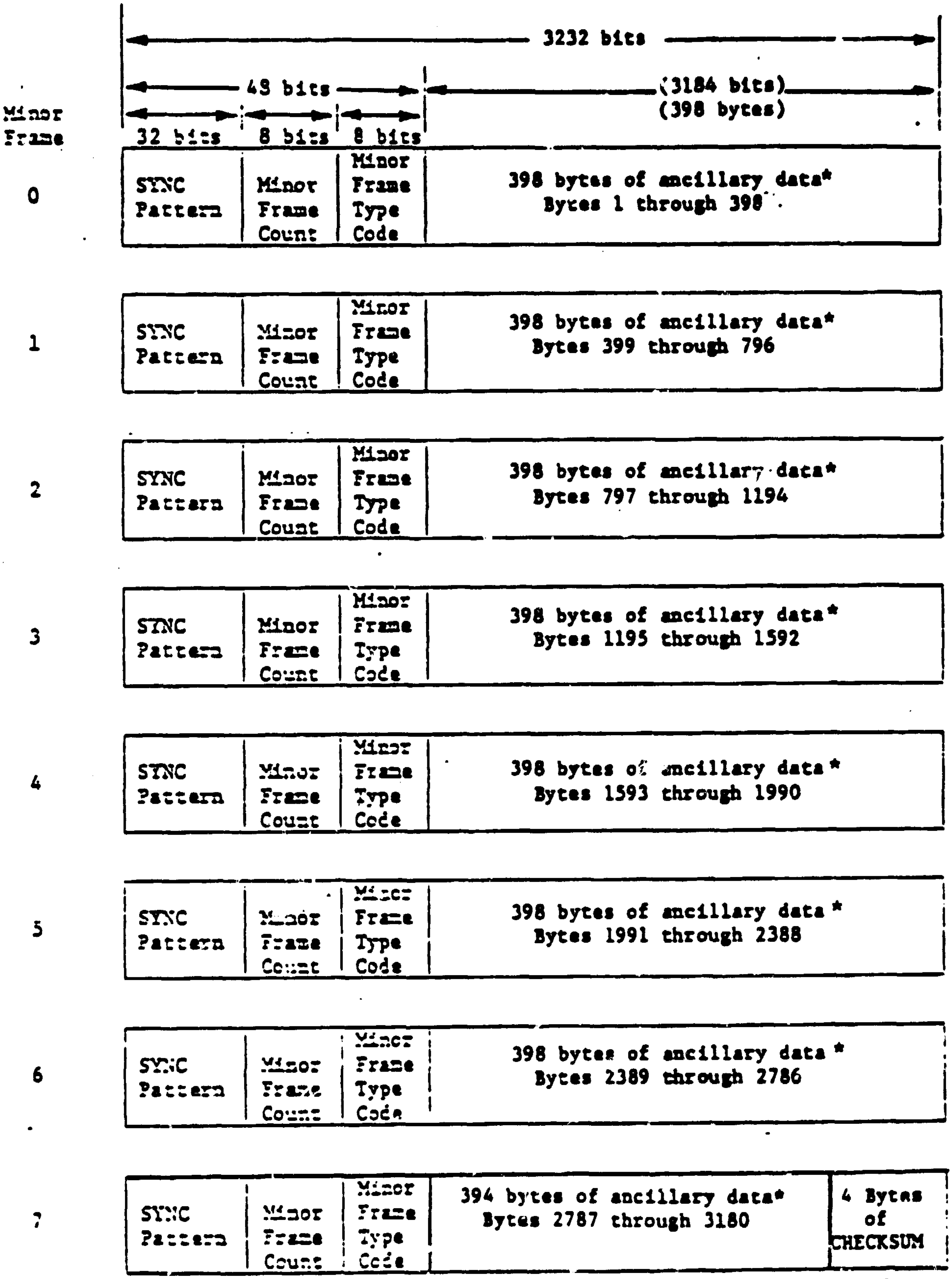
3.3.4.1 Geometric Modeling Data

As indicated above, the first two major frames of ancillary data contain geometric modeling data. The data elements that comprise this section are delineated in Table 3.3-6. The first major frame contains a set of "universal" spacecraft constants, the values of these constants are given in Table 3.3-7. The second major frame contains spacecraft parameters related to the individual scene.

A discussion of the geometric correction process is given in Data Format Control Book, Volume VI, Products (reference paragraph 2.2.b).

3.3.4.2 Projection Data

Major frames 3 through 10 support either the UTM or PS map projection and are



*Byte allocations are described in Tables 3.3-6 and 3.3-8.

Figure 3.3-4. One Major Frame of Ancillary

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Table 3.3-6. Geometric Modeling Ancillary Data Elements

Ancillary Major Frame 1		Contains sensor related constants used in geometric correction - not scene dependent.
Bytes	Data Representation*	Data Description
1 - 4	FP	Nominal number of pixels per input line
5 - 8	FP	Number of input lines in the partially processed image
9 - 16	FL	Nominal scale of input inter-pixel distance in meters per pixel
17 - 24	FL	Nominal scale of input inter-line distance in meters per pixel
25 - 28	FP	Number of pixels per output line of fully processed image
29 - 32	FP	Number of lines per output image of fully processed image
33 - 40	FL	Scale of fully processed output inter-pixel distance in meters per pixel
41 - 48	FL	Scale of fully processed output inter-line distance in meters per pixel
49 - 56	FL	Nominal spacecraft altitude in meters
57 - 64	FL	Nominal input swath width in meters
65 - 96	FL	MSS mirror model coefficients (4 values, 8 bytes each) 4 FL format zeros
97 - 104	FL	MSS maximum mirror angle in radians
105 - 112	FL	Scan skew constant (as a result of finite scan time)
113 - 120	FL	Time between successive MSS mirror sweeps in seconds
121 - 128	FL	Time for the active portion of an MSS mirror sweep in seconds
129 - 136	FL	Semi-major axis of Earth ellipsoid (International Spheroid)
137 - 144	FL	Semi-minor axis of Earth ellipsoid (International Spheroid)
145 - 152	FL	Earth curvature constant (dependent on space-craft's nominal altitude and Earth radius)
153 - 248	FLS	MSS sampling delay constants (24 values, one for each detector) measured in input image along-scan pixel units (4 bytes each)
249 - 256	—	Zero fill
257 - 268	FLS	MSS band-to-band offsets with respect to band I (3 values: one each for bands 2, 3, 4) measured in input image along-scan pixel units
269 - 3180	—	Zero fill
3181 - 3184	Binary	Checksum for Bytes 1-3180

* FL = Floating Point Binary Format
FLS = Single Precision Floating Point Binary Format
FP = Fixed Point Binary Format
Reference paragraph 3.2.3.4

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Table 3.3-6. Geometric Modeling Ancillary Data Elements (Cont'd)

Ancillary Major Frame 2		Contains scene dependent parameters
Bytes	Data Representation*	Data Description
1 - 8	ASCII	WRS frame and orbit numbers bPPP-path, bRRR=row
9 - 16	FL	WRS center latitude in radians
17 - 24	FL	WRS center longitude in radians
25 - 40	ASCII	Spacecraft time of frame center (Universal time), same format as bytes 71-86 in Header
41 - 48	—	Zero fill
49 - 56	FL	Scene Center latitude in radians**
57 - 64	FL	Scene Center longitude in radians
65 - 88	FL	Scene Center in Earth-centered Earth-fixed coordinates in meters (3 values, 8 bytes each)
89 - 96	FL	Spacecraft heading angle at scene center (beta) in radians
97 - 104	FL	Scan line coordinate of scene center in partially processed image
105 - 112	FL	Pixel coordinate of scene center in partially processed image
113 - 120	FL	Normalized spacecraft velocity error from nominal at nadir
121 - 128	FL	Earth rotation velocity at nadir in meters per second
129 - 132	FLS	The Earth rotation parameter (image skew), in radians
		Spacecraft state vector at scene center:
133 - 140	FL	Pitch in radians
141 - 148	FL	Roll in radians
149 - 156	FL	Yaw in radians
157 - 164	FL	X in Km
165 - 172	FL	Y in Km
173 - 180	FL	Z in Km
181 - 188	FL	Delta pitch in radians/sec
189 - 196	FL	Delta roll in radians/sec
197 - 204	FL	Delta yaw in radians/sec
205 - 212	FL	Delta X in Km/sec
213 - 220	FL	Delta Y in K/sec
221 - 228	FL	Delta Z in Km/sec
228 - 244		Zero Fill
245 - 248	FP	Total number of CPs used in attitude/ephemeris fit
249 - 252	FP	Number of GCPs used
253 - 256	FP	Total number of CP correlations attempted
257 - 260	FP	Number of correlated CPs rejected during modeling process (i.e., outside predefined limits, indicating an undesireable CP for some reason)
261 - 264		RMS along-track geometric modeling error (i.e., how well the geometric model matched the CP data), in meters
265 - 268		RMS across-track geometric modeling error, in meters
269 - 275		Zero Fill

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Table 3.3.-6. Geometric Modeling Ancillary Data Elements (Cont'd)

Ancillary Major Frame 2			Contains scene dependent parameters
Bytes	Data Representation*		Data Description
276 - 300	Binary		Distribution of CPs used. The number of CPs in each zone of the WRS frame is given (one byte per zone)
301-500	ASCII		Identification of CPs used. Up to 25 CP's each using eight bytes of the format ƀBTXXYYY where ƀ = blank; B = Band number 1,2,3,or4; T = Type (G,S,R); XX = Zone 01-25; YYY = Sequence within Scene 001-999
501 - 600	—		Zero Fill
601 - 600	—		Zero Fill
			Geometric Correction Parameters***
			Ephemeris Data:
			Time of the first set of ephemeris entries in ASCII
661 - 662	Yr.	Yr.	
663 - 664	D	D	
665 - 666	Hr	Min	
669 - 670	Min	Sec	
671 - 672	Sec	Msec	
673 - 674	Msec	Msec	
675 - 678	FLS		Time interval between successive sets of ephemeris entries (in seconds)
679 - 682	FP		Number of sets of ephemeris entries
683 - 1130			Up to 16 sets of ephemeris entries, each set consists of seven values: spacecraft location (x,y,z) in FLS format, spacecraft velocity (X_x, V_y, V_z)in FLS format and a data quality indicator in FP format. Coordinate system is Earth-centered, Earth-fixed.
			Attitude Data:
1131 - 1132	Yr.	Yr.	Time of the first set of attitude entries in ASCII.
1133 - 1134	D	D	
1135 - 1136	D	Hr	
1137 - 1138	Hr	Min	
1139 - 1140	Min	Sec	
1141 - 1142	Sec	Msec	
1143 - 1144	Msec	Msec	

* FL = Floating Point Binary Format
FLS = Single Precision Floating Point Binary Form
FP - Fixed Point Binary Format
Reference paragraph 3.2.3.4
** All references refer to nadir at time of frame center.
*** Needed for certain retrospective control point library build situations.
Unused bytes are zero filled.

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Table 3.3.-6. Geometric Modeling Ancillary Data Elements (cont'd)

Ancillary Major Frame 2		Contains scene dependent parameters
Bytes	Data Representation*	Data Description
1145 - 1148	FLS	Time interval between successive sets of attitude entries, in seconds
1149 - 1152		Number of sets of attitude entries
1153 - 2112		Up to 60 sets of attitude entries, each set consists of four values: pitch angle (radians) in FLS format, roll angle (radians) in FLS format, yaw angle (radians) in FLS format, and a data quality indicator in FP format.
2113 - 2832	FLS	Partial derivates for SOM projection. There are 12 matrices, each matrix is 3 x 5. The 12 matrices are partial derivatives of X and Y with respect to each of six spacecraft parameters: along-track location, across-track location, altitude, pitch, roll, yar.
2833 - 3000	Zero Fill	Zero fill - not used
3001 - 3048	FLS	Multiplicative and additive radiometric correction constants, two values for each of six detectors in the order: Detector 1 multiplicative constant, Detector 1 additive constant, Detector 2 multiplicative constant, etc.
3049 - 3180	Zero Fill	Zero fill - not used
3181 - 3184	Binary	Checksum for Bytes 1-3180

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Table 3.3.-7. Spacecraft and Sensor Constants

Data Description	Values*
Nominal number of pixels per input line	3240
Number of input lines in the partially processed image	2400
Nominal scale of input inter-pixel distance in meters per pixel	57
Nominal scale of input inter-line distance in meters per pixel	82.7
Number of pixels per output line of fully processed image	3548
Number of lines per output image of fully processed image	2983
Scale of fully processed output inter-pixel distance in meters per pixel	57
Scale of fully processed output inter-line distance in meters per pixel	57
Nominal spacecraft altitude in meters	705300
Nominal input swath width in meters	185000
MSS mirror model coefficients (Zero filled for Landsat-D)	
MSS maximum mirror angle in radians	.260
Scan skew constant in radians	.00135]35
Time between successive MSS mirror sweeps in seconds	.07342
Time for the active portion of an MSS mirror sweep in seconds	.03226
Semi-major axis of Earth ellipsoid (International Spheroid) in meters	6378388
Semi-minor axis of Earth ellipsoid (International Spheroid) in meters	6356912
Earth curvature constant in meters^{-2}	$-1.113315 \times 10^{-13}$
MSS sampling delay constants (24 values, one for each detector) measured in input image along-scan pixel units. The MSS sampling delay constants will appear in the following order	
Band 1 detector 1	-.4592
Band 1 detector 2	-.3793
Band 1 detector 3	-.2995
Band 1 detector 4	-.2196

Table 3.3-7. Spacecraft and Sensor Constants (cont'd)

Data Description	Values*
Band 1 detector 5	-.1398
Band 1 detector 6	-.0599
Band 2 detector 1	-.4193
Band 2 detector 2	-.3394
Band 2 detector 3	-.2595
Band 2 detector 4	-.1797
Band 2 detector 5	-.0998
Band 2 detector 6	-.0200
Band 3 detector 1	.0200
Band 3 detector 2	.0998
Band 3 detector 3	.1797
Band 3 detector 4	.2595
Band 3 detector 5	.3394
Band 3 detector 6	.4193
Band 4 detector 1	.0599
Band 4 detector 2	.1398
Band 4 detector 3	.2196
Band 4 detector 4	.2945
Band 4 detector 5	.3793
Band 4 detector 6	.4592
MSS band-to-band offsets with respect to band 1 (3 values: one each for bands 2, 3, 4) measured in input image along-scan pixel units	band 2 = 1.99 band 3 = 4.37 band 4 = 6.36

*For Landsat-D, values for Landsat-D Prime are TBD.

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Table 3.3-8. Detailed Ancillary Data Elements,
Major Frames 3 Through 10 and 11 Through 18

Major Frame Number	Bytes	Row Number	Data Description
3, 11	1 - 244	1	HRS Pixel Coordinates*
	245 - 248	1	Line Fill Left Count*
	249 - 252	1	Line Fill Right Count*
	253 - 496	2	HRS Pixel Coordinates*
	497 - 500	2	Line Fill Left Count*
	501 - 504	2	Line Fill Right Count*
	505 - 756	3	HRS Coordinates*, Counts*
	757 - 3024	4 - 12	HRS Coordinates*, Counts*
	3025 - 3180	—	Zero Fill
	3181 - 3184	—	CHECKSUM
4, 12	1 - 3024	13 - 24	HRS Coordinates*, Counts*
	3025 - 3180	—	Zero Fill
	3181 - 3184	—	CHECKSUM
5, 13	1 - 3024	25 - 36	HRS Coordinates*, Counts*
	3025 - 3180	—	Zero Fill
	3181 - 3184	—	CHECKSUM
6, 14	1 - 3024	37 - 48	HRS Coordinates*, Counts*
	3025 - 3180	—	Zero Fill
	3181 - 3184	—	CHECKSUM
7, 15	1 - 756	49 - 51	HRS Coordinates*, Counts*
	757 - 1008	—	Zero Fill
	1009 - 1252	1	VRS Line Coordinates*
	1253 - 2960	2 - 8	VRS Coordinates*
	2961 - 3180	—	Zero Fill
	3181 - 3184	—	CHECKSUM
8, 16	1 - 2928	9 - 20	VRS Coordinates*
	2929 - 3180	—	Zero Fill
	3181 - 3184	—	CHECKSUM
9, 17	1 - 2928	21 - 32	VRS Coordinates*
	2929 - 3180	—	Zero Fill
	3181 - 3184	—	CHECKSUM

*Each coordinate and grid line fill count is in the fixed point format discussed in paragraph 3.2.3.4.4.

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Table 3.3-8. Detailed Ancillary Data Elements, Major Frames 3 Through 10, and 11 Through 18 (cont'd)

Major Frame Number	Bytes	Row Number	Data Description
10,18	1 - 2928	33 - 44	VRS Coordinates *
	2929 - 3072	—	Zero Fill
	3073 - 3074		Pixel Number of WRS Center in fully Processed Image (binary)
	3075 - 3076		Offset of WRS Center from Fully Processed Image Center Pixel (in pixel units).**Displacement of the World Reference System designation with respect to the picture center pixel (scan line 1492, pixel 1774). Most significant bit indicates the sign; "0" = positive with WRS center to right of picture center and "1" = negative with WRS center to left of picture center (binary).
	3077 - 3096		Temporal Registration Scene ID in the format shown in header bytes 1 through 20.
	3097 - 3128		Scan line and pixel numbers for the common temporal registration region of the referenced image and current image (image under processing, see Figure 3.3.-5). The values of temporal registration corners P_1 through P_4 are in the tabular form given below. Entries denote byte assignments for binary scan line numbers and pixel numbers.

Temporal Registration Corners	Current Image		Reference Image	
	Scan Line Number	Pixel Number	Scan Line Number	Pixel Number
P_1	3097-3098	3099-3100	3101-3102	3103-3104
P_2	3105-3106	3107-3108	3109-3110	3111-3112
P_3	3113-3114	3115-3116	3117-3118	3119-3120
P_4	3121-3122	3123-3124	3125-3126	3127-3128

Major Frame Number	Bytes	Row Number	Data Description
—	3129 - 3144		Overlap data: (See Figure 3.3-6) scan line and pixel numbers (in binary) of the four overlap marks as follows:
	3129-3130		Scan Line of First Overlap Mark (Upper Left)
	3131-3132		Pixel Number of First Overlap Mark
	3133-3134		Scan Line of Second Overlap Mark (Upper Right)

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Table 3.3-8. Detailed Ancillary Data Elements, Major Frames 3 Through 10, and 11 through 18 (cont'd)

Major Frame Number	Bytes *	Row Number	Data Description
	3135-3136		Pixel Number of Second Overlap Mark
	3137-3138		Scan Line of Third Overlap Mark (Lower Left)
	3139-3140		Pixel Number of Third Overlap Mark
	3141-3142		Scan Line of Fourth Overlap Mark (Lower right)
	3143-3144		Pixel Number of Fourth Overlap Mark
	3145 - 3148		Actual Number of Tick Marks. One byte for each edge; top, left, right, and bottom. (binary)
	3149 - 3156		Input sample value of 4 Corner Points in Output Image (Location of image date within output array) (Band Independent) (binary)
	3157 - 3164		Image Orientation Angle Orientation of map projection co-ordinate system with respect to center line of fully processed image (Beta angle, in radians). Floating point binary format.
	3165 - 3166		NSWEEPS - The number of sweeps prior to scene center at which the grid points begin (always 184)
	3167 - 3180		Zero Fill
	3181 - 3184		CHECKSUM (binary)

*Each coordinate is in the fixed point format discussed in paragraph 3.2.3.4.4
**See Figures 3.3-5 and 3.3-6 for illustration.

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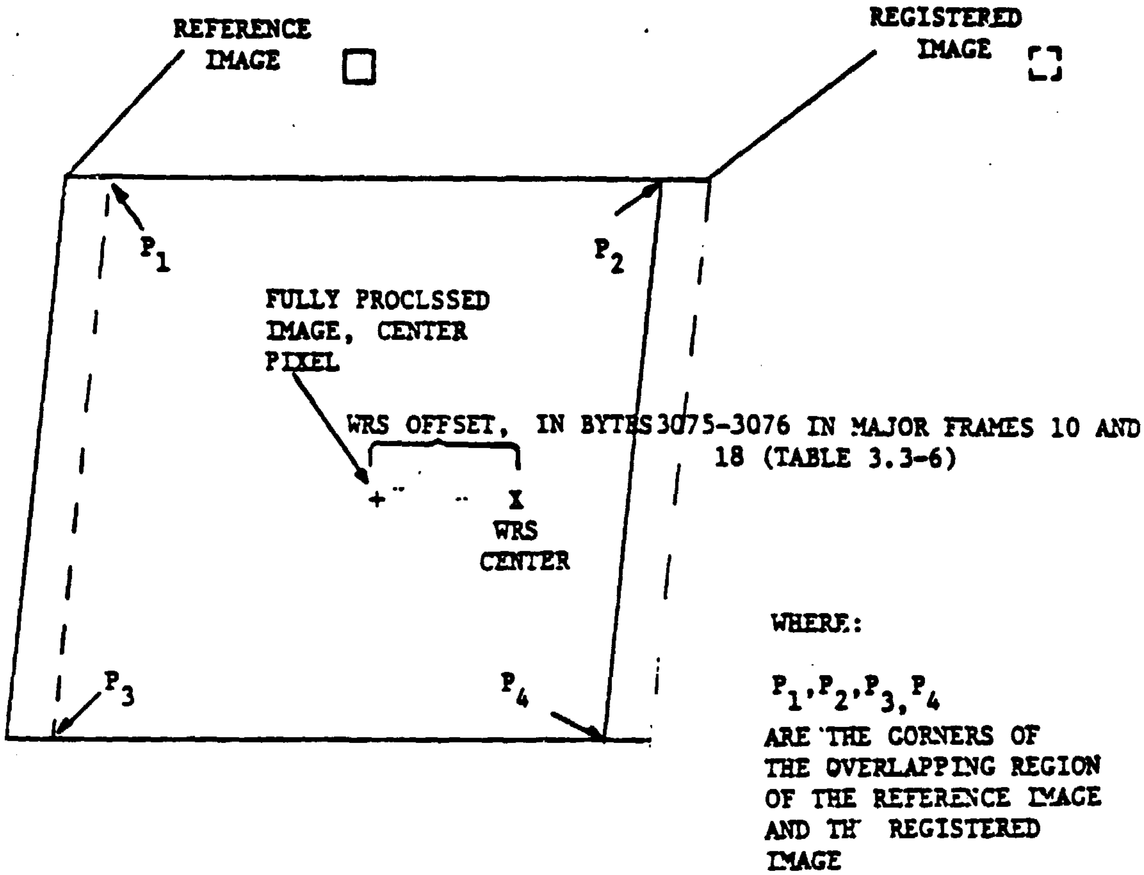

Figure 3.3-5. Symbolic Representation of Temporal Registration

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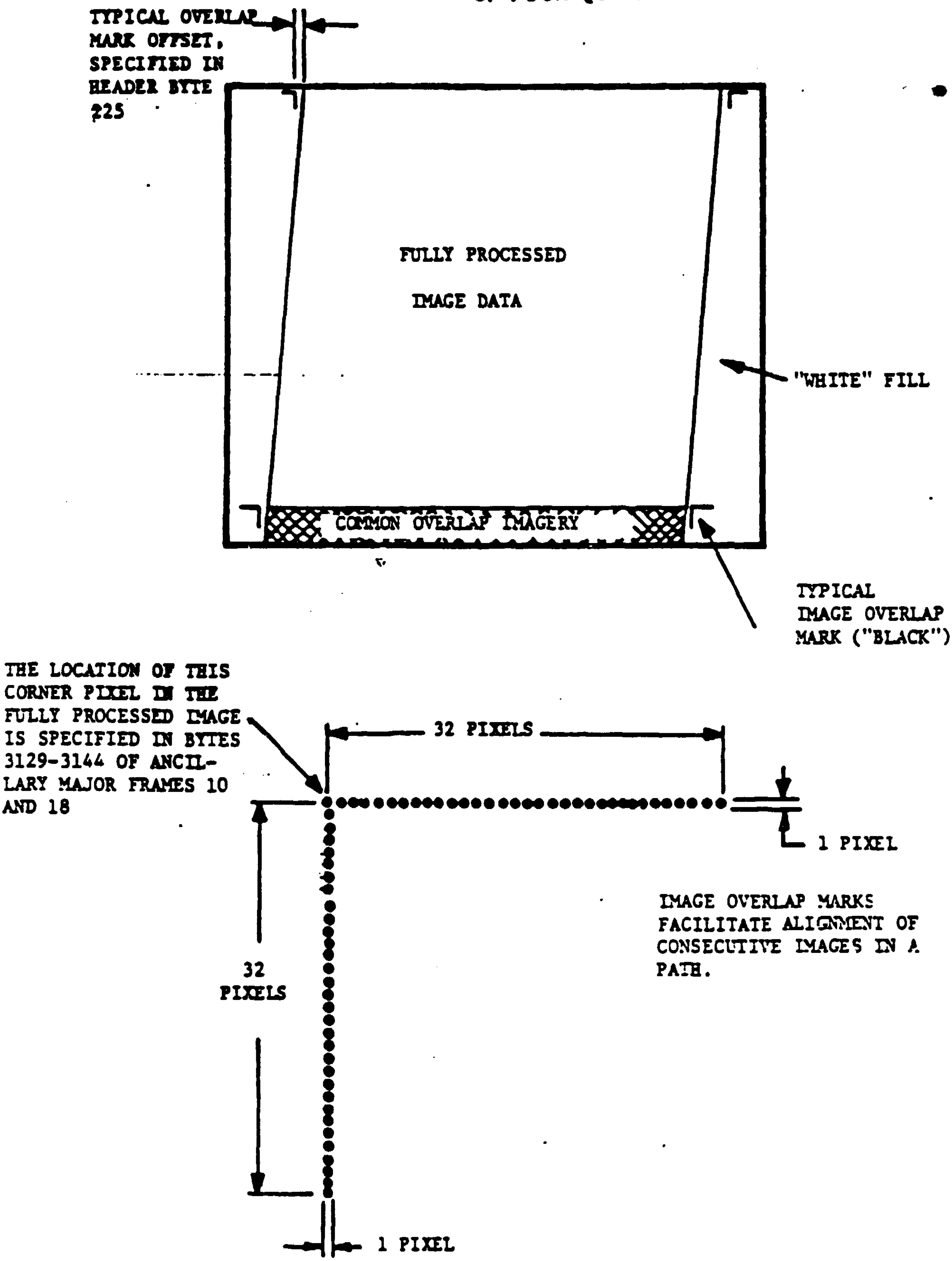

Figure 3.3-6. Image Overlap Marks and Common Overlapping Imagery

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logically coupled to the first major frame of annotation data. Major frames 11 through 18 support the SOM map projection and are logically coupled to the second major frame of annotation data. Major frames 19-26 are zero filled and reserved as spares. Byte 118 in the header (Table 3.3.-2) designates the projection type (PS or UTM) found in major frames 3 through 10. Each set of eight projection data major frames contains the following information:

a. Horizontal Resampling (HRS) grid. The HRS grid is a 51 by 61 element array that defines input pixel number as a function of position in hybrid space. The HRS values are biased by half the nominal line length plus one, and are therefore zero at nominal midscan - 12444 bytes.

b. Vertical Resampling (VRS) grid. The VRS is a 44 by 61 element array that defines input line number as a function of position in output space. The VRS values are biased by the number of sweeps prior to scene center in the useful data. This bias is stored in NSWEEPS (bytes 3165-3166) in Ancillary major frames 10 and 18) - 10736 bytes.

c.	51 Left fill counts	204 bytes
d.	51 Right fill counts	204 bytes
e.	Pixel number of WRS center	2 bytes
f.	WRS offset from image center	2 bytes
g.	Temporal registration scene identification	20 bytes
h.	Corners of temporally registered area	32 bytes
i.	Location of image overlap marks	16 bytes
j.	Actual number of tick marks	4 bytes

k.	Corners of fully processed image area	8 bytes
l.	Orientation of map projection coordinate system	8 bytes
	TOTAL	23680 bytes

Table 3.3.-8 gives the details of these major frames. It should be noted that the ERS and VRS pixel coordinates and the line fill counts are given in two's complement notation.

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g.	Temporal registration scene identification	– 20 bytes
h.	Corners of temporally registered area	– 32 bytes
i.	Location of image overlap marks	– 16 bytes
j.	Actual number of tick marks	– 4 bytes
k.	Corners of fully processed image area	– 8 bytes
l.	Orientation of map projection coordinate system	– 8 bytes
	TOTAL	– 23680 bytes

Table 3.3.-8 gives the details of these major frames. It should be noted that the HRS and VRS pixel coordinates and the line fill counts are given in two's complement notation.

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3.3.5 ANNOTATION DATA

Two structurally identical major frames of annotation data follow the ancillary section, one complete major frame for each map projection - UTM or PS (as indicated in byte 118 in the header) - followed by SOM. When the framed image data covers sites north of 65^oN latitude or south of 65^oS latitude, PS values are given in place of UTM values. Each major frame contains both the alphanumeric information printed at the bottom of a film product and information about the tick marks which surround the fully processed framed image. Figure 3.3-7 illustrates the location of both the annotation and the tick mark information relative to the fully processed image writing area, independent of map projection.

An example of a major frame of annotation is given in Figure 3.3-8. The first minor frame of annotation data, containing the 115 bytes of annotation data that is printed at the bottom of a film product, is fully illustrated in Table 3.3-9 and Figure 3.3-9. The data content of the next six minor frames is limited to the tick marks that surround the fully processed image. An example of a major frame of annotation is given in Figure 3.3-9.

Pixel 1, scan line 1 in the fully processed image is the point to which all tick mark information is referenced. Each tick mark is located approximately 1000 meters from the fully processed image area. The exact distances, measured from the center of the edge pixel in the image area to the tick mark, are: 997.5 meters (17.5 pixels) on the bottom and right sides and 1054.5 meters (18.5 pixels) on the top and left sides. Figure 3.3-10 illustrates tick mark features and their utilization in a fully processed (i.e., geometrically corrected)

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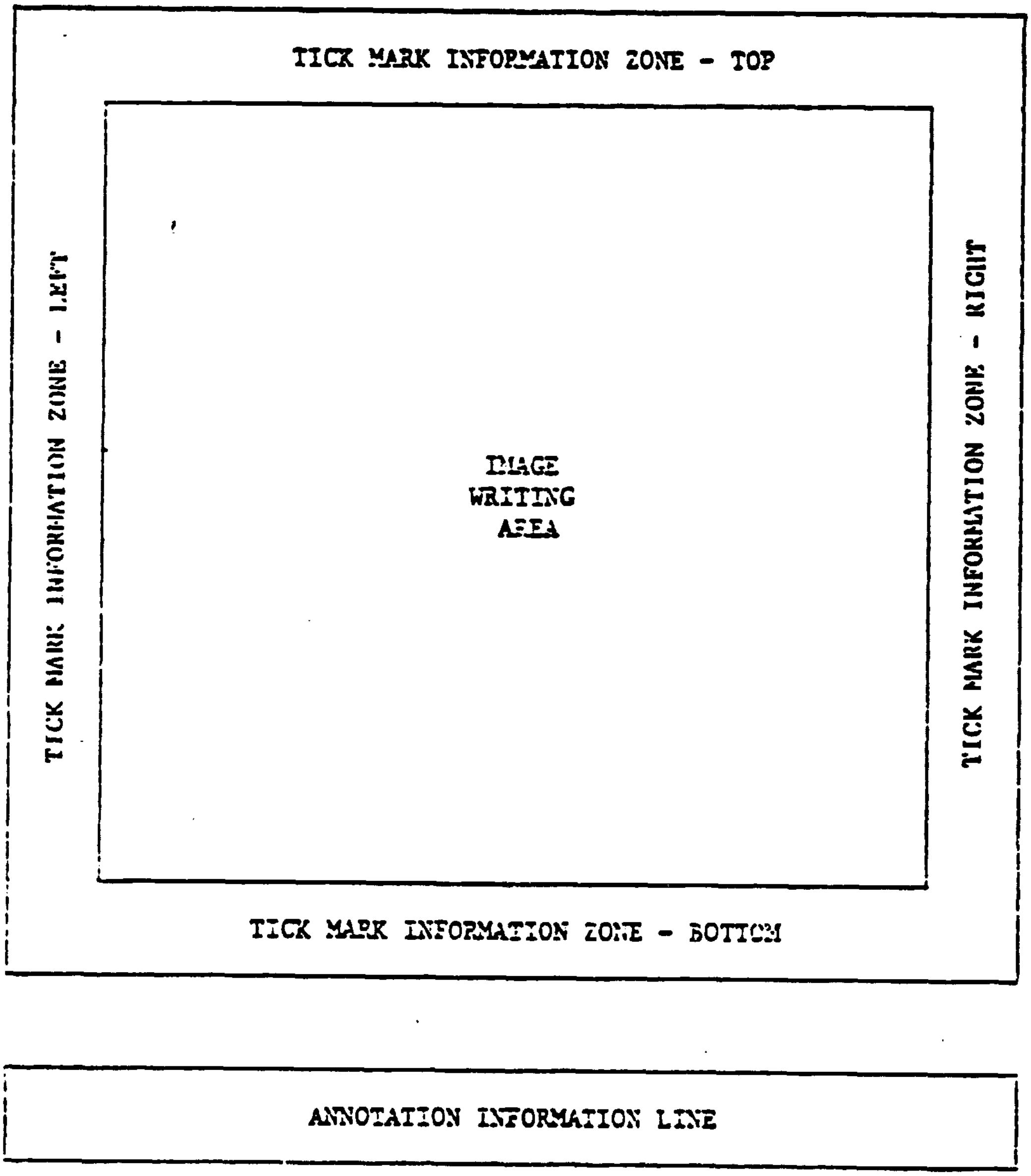

Figure 3.3-7. Relationship Between Annotation Information and Image Writing Area

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3232 bits

48 bits | (3184 bits) (398 bytes)

Minor Frame	32 bits	8 bits	8 bits	(3184 bits) (398 bytes)		
0	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Annotation Line Data (115 bytes) See Table 3.3-7.		Zero Fill (283 bytes)
1	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Top Edge Tick Mark Data 16 Coordinates (9 bytes each) (144 bytes)		Zero Fill (254 bytes)
2	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Left Side Tick Mark Data, First 18 Coordinates (9 bytes each) (162 bytes)		Zero Fill (236 bytes)
3	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Left Side Tick Mark Data, Concluding 7 Coordinates (9 bytes each) (63 bytes)		Zero Fill (335 bytes)
4	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Right Side Tick Mark Data, First 18 Coordinates (9 bytes each) (162 bytes)		Zero Fill (236 bytes)
5	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Right Side Tick Mark Data, Concluding 7 Coordinates (9 bytes each) (63 bytes)		Zero Fill (335 bytes)
6	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Bottom Edge Tick Mark Data, 16 Coordinates (9 bytes each) (144 bytes)	4 Bytes of CHECKSUM	Zero Fill 250 bytes
7	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Zero Fill (398 bytes)		

Figure 3.3-8. One Major Frame of Annotation

Table 3.3-9. Detailed Explanation of the 115 Character Annotation Field (Also see Figure 3.3-9.)

FIELD	CHARACTER POSITION	EXAMPLE	EXPLANATION
a	01 - 08	07JUN82Ƀ	Day, month and year of image acquisition
b	09 - 25	CɃN33-Ø5/W115-18Ƀ	Image Format Center - Latitude and longitude of the center of the MSS image format in degrees and minutes.
c	26 - 34	D202-101Ƀ	WRS path and row identifier and orbital direction indicator. The "D" indicates spacecraft is descending, an "A" indicates spacecraft is ascending. The 202 is path number and 101 is row number.
d	35 - 51	NɃN33-Ø3/W115-42Ƀ	WRS center latitude and longitude
e	52 - 61	MɃ1234ɃɃDɃ	Sensor (MSS) and spectral band identification code. There are separate characters for each band, this example shows the position of each band identifier; normally only one character is present. The "D" indicates direct transmission from the spacecraft (not stored onboard before transmission).
f	62 - 75	SUNɃEL3ØɃAØ15Ƀ	Sun Angles - the sun elevation angle and sun azimuth angle measured clockwise from true North at time of midpoint of MSS frame is specified to the nearest degree. Blank for ascending node coverage.
g	76 - 87	UɃP-ɃD-NɃL2Ƀ	PROCESSING CODES (These codes apply to the geometric correction matrix values and to the final gemetrically corrected image data.)
	76		Character position 76 defines the type of geometric correction applied to the data: "U" = uncorrected "S" = system level corrected "G" = geometrically corrected based on geodetic information (no temporal registration performed) "T" = temporal registration using geodetic information from a single reference scene "R" = temporal registration to a single reference scene (no geodetic information available)
	78		Character position 78 defines the projection: "P" = Polar stereographic projection "S" = Space Oblique mercator projection "U" = Universal Transverse Mercator projection

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Table 3.3-9. Detailed Explanation of the 115 Character Annotation Field (cont'd)

FIELD	CHARACTER POSITION	EXAMPLE	EXPLANATION
	80		Character position 80 indicates the resampling algorithm; always blank for geometrically uncorrected data.
	81		Character position 81 indicates the type of ephemeris data used to compute the geometric correction matrices. "P" = predictive "D" = definitive "G" = GPS
	83		Character position 83 gives the processing procedure: "N" = normal processing procedure "A" = abnormal processing procedure
	85		Character position 85 indicates the sensor gain: "H" = high gain "L" = low gain
	86		Character position 86 shows the type of MSS transmission: "1" = linear mode "2" = compressed mode
h	88 - 100	NASAbLANDSATb	Identifies the Agency and the Project
i	101 - 115	E-N1042-16032-1	Frame identification number - each image or frame will have a unique identifier which will contain encoded information consisting primarily of time of acquisition (Universal Time) relative to launch. Its format is E-NDDDD-HHMMS-B and is interpreted as follows: "E" = Encoded Project Identifier N = Landsat Mission Number DDDD = Day number, relative to launch, at time of observation HH = Hour at time of observation MM = Minute at time of observation S = Tens of seconds at time of observation B = Band identification code (MSS): 1, 2, 3, 4

DATA FIELD:	a	b	c	d	e	f	g	h	i
CHARACTER POSITION:	12345678	11111111111222222 90123456789012345	222233333 678901234	33333444444444455 56789012345678901	5555555566 2345678901	66666666777777 23456789012345	777788888888 678901234567	1 8899999999990 8901234567890	111111111111111 000000000111111 123456789012345
EXAMPLE:	07JUN82	C N33-05/W115-18	D202-101	N N33-03/W115-42	N 1 D	SUN EL30 A015	U S-CD-N L2	NASA LANDSAT	E-41042-16032-1
OTHER POSSIBLE DATA ELEMENTS			A	2 3 4			S P NP A N1 R U G G T		2 3 4

Figure 3.3-9. The 115 Character Annotation Field

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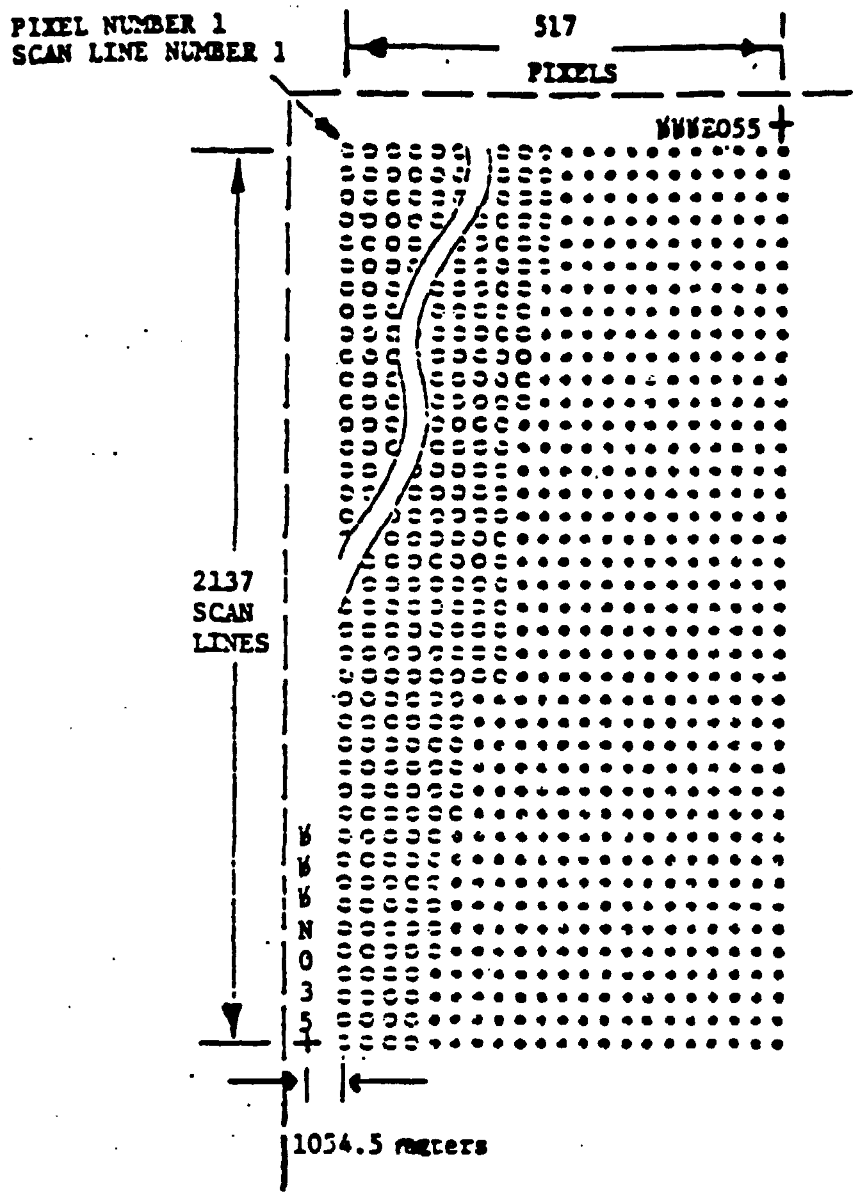

ANNOTATION FORMAT AND LOCATION WITH RESPECT TO TICK MARK*

BINARY LOCATION OF TICK MARK

COORDINATE DATA (LEADING BLANKS FORMAT SHOWN)

TOP	10000010	00000101	ƀ	ƀ	ƀ	E	0	5	5
SIDE	10001000	01011001	ƀ	ƀ	ƀ	N	0	3	5

*WHEN MSB = 1, ANNOTATION IS ABOVE OR TO LEFT OF TICK MARK WITH LEADING BLANKS.
WHEN MSB = 0, ANNOTATION IS BELOW OR TO RIGHT OF TICK MARK WITH TRAILING BLANKS.

Figure 3.3-10. An Example of the Placement of Two Tick Mark Coordinates and Their Corresponding Annotation with Respect to Fully Processed Image Data

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image. As shown at the bottom of Figure 3.3-10, the most significant bit in the binary tick mark location bytes specifies the placement and format of the coordinate data. Specifically, a "0" signifies the annotation is either below or to the right of the tick mark with trailing blanks and a "1" signifies the annotation is either above or to the left of the tick mark with leading blanks. Tick mark annotation examples for each of the map projections are provided in Figure 3.3-11.

In the annotation major frame, space has been reserved for 16, 25, 25, and 16 tick marks on the top, left, right and bottom sides respectively. In actual practice no more than ten tick marks will be provided on each of the four sides, in minor frames one, two, four, and six. Within each of these minor frames the tick mark data is left justified (with respect to the minor frame) and all unused data fields will be zero filled. The concluding minor frame (number seven) is zero filled. The order of tick mark data, both in appearance in the respective minor frame and on the image product, is summarized below:

TICK MARK ZONE	ORDER OF APPEARANCE
Top	Left to right
Left	Top to bottom
Right	Top to bottom
Bottom	Left to right

3.3.6 IMAGE DATA

The image data section contains the radiometrically corrected image data as well

UTM Tick Mark (ASCII Notation)

X	X	N E	0	3	5	b̸	b̸	b̸

3 blanks (trailing blank format)

Coordinate - ranges from 000 to 995 in increments of 5; scale factor is 10^4 m (therefore, value shown represents 350,000m)

Either N for Northing (sides) or
E for Easting (top and bottom)

Binary Location of the Tick Mark:
Either Pixel Number for Top or Bottom Edge
or Line Number for Left or Right Side

NOTE: LEADING BLANK FORMAT IS AS IN FIGURE 3.3-10.

Polar Stereographic Tick Mark (ASCII Notation)

X	X	X Y	+ -	0	3	5	b̸	b̸

2 blanks (trailing blank format)

Coordinate - same as in UTM

Quadrant Sign of Coordinate

Either X or Y, both can appear on any edge

Binary Location of Tick Mark - same as in UTM

NOTE: LEADING BLANK FORMAT IS SIMILAR TO FIGURE 3.3-10.

Figure 3.3-11. Tick Mark Annotation

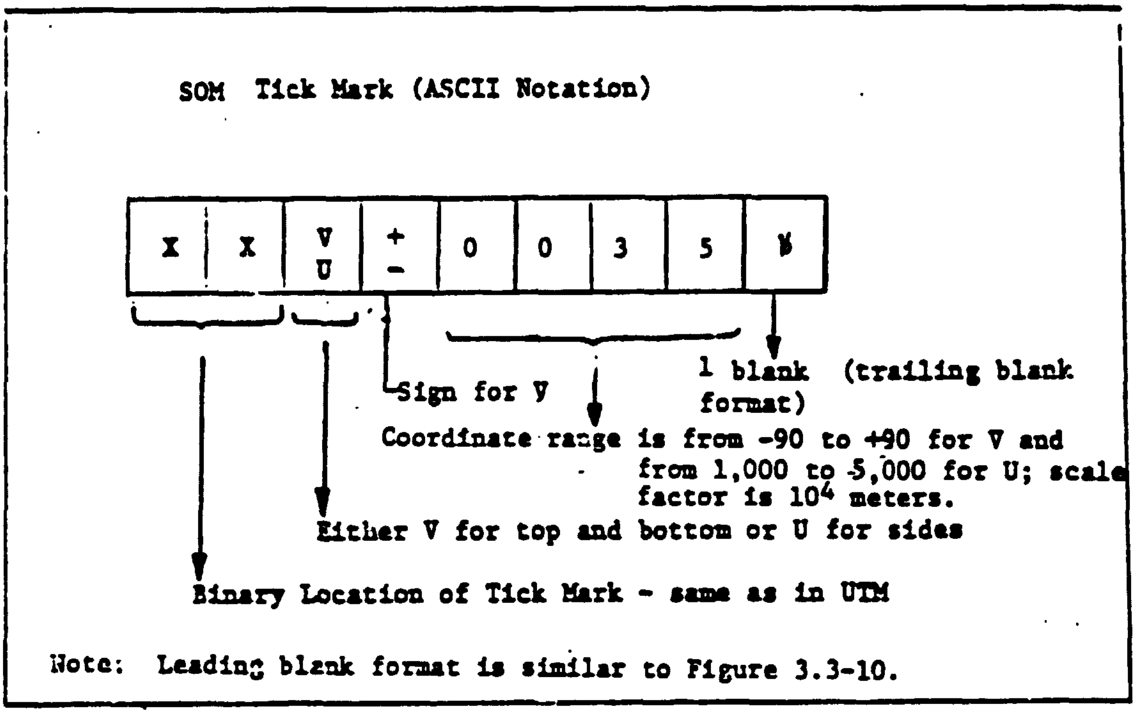

Figure 3.3-11. Tick Mark Annotation (continued)

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as quality and calibration information. Each major frame of image data contains all the pixels in a scan line from a single detector. All minor frames of image data (as shown in Figure 3.3-12) begin with six eight-bit bytes of standard identification information: sync pattern, minor frame count, and minor frame type code. This field is followed by a 48-bit scan line identification (SLID) that uniquely identifies each scan line. Thus, each minor frame of image data has the first 96 bits reserved for identification information. The SLID format is shown in Figure 3.3-13. Specifically, it contains the spacecraft time, a band indicator, and a binary count. The 40-bit spacecraft time updates every alternate mirrow sweep (or every 12 major frames). To provide the unique scan line(major frame) identification, a four-bit count is utilized. The count starts at one and is incremented by one every major frame until the binary count reaches 12. The first scan line in an image is always from detector one and has a count of one.

As shown in Figure 3.3-12, space for up to 3548 seven-bit pixels is provided in each major frame (448 pixels in minor frames 0 through 6 and 412 pixels in minor frame 7). Compressed pixels will have been decompressed into seven-bit pixels. Six-bit pixels received in the linear mode have a zero as the MSB.

For Landsat-D and D Prime, two options are available to determine the gain and bias values for each detector which are then used to radiometrically calibrate the input image data. Tht first uses the calibration wedge while the second uses histograms of image data. Byte 147 in the header indicates which option was used. The support data for each image data major frame contains both sets of gain and offset values (see Table 3.3-10). A discussion of the radiometric

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as quality and calibration information. Each major frame of image data contains all the pixels in a scan line from a single detector. All minor frames of image data (as shown in Figure 3.3-12) begin with six eight-bit bytes of standard identification information: sync pattern, minor frame count, and minor frame type code. This field is followed by a 48-bit scan line identification (SLID) that uniquely identifies each scan line. Thus, each minor frame of image data has the first 96 bits reserved for identification information. The SLID format is shown in Figure 3.3-13. Specifically, it contains the spacecraft time, a band indicator, and a binary count. The 40-bit spacecraft time updates every alternate mirror sweep (or every 12 major frames). To provide the unique scan line (major frame) identification, a four-bit count is utilized. The count starts at one and is incremented by one every major frame until the binary count reaches 12.

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3232 bits

48 bits | 3136 bits

Minor Frame	32 bits	8 bits	8 bits	48 bits	3136 bits	
0	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Scan Line ID	448 Image Pixels	
1	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Scan Line ID	448 Image Pixels	
2	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Scan Line ID	448 Image Pixels	
3	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Scan Line ID	448 Image Pixels	
4	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Scan Line ID	448 Image Pixels	
5	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Scan Line ID	448 Image Pixels	
6	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Scan Line ID	448 Image Pixels	
7	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Scan Line ID	412 Image Pixels	252 bits of Support Data*

SLID - Reference Figure 3.3-12.

* Reference Table 3.3-10.

Figure 3.3-12. One Major Frame of Image Data

	MSB 15–12	11–8	7–4	3–0 LSB
WORD 0:	HD	TD	UD	TH
WORD 1:	UH	TM	UM	TS
WORD 2:	US	HMIL	BAND	CTR

where: HD = hundreds of days
TD = tens of days
UD = units of days
TH = tens of hours
UH = units of hours
TM = tens of minutes
UM = units of minutes
TS = tens of seconds
US = units of seconds
HMIL = hundreds of milliseconds
BAND = band indicator (4 bits)
where: band 1 = 0001
band 2 = 0010
band 3 = 0011
band 4 = 0100
CTR = binary counter that identifies each of the 12 scan lines generated during two mirror sweeps. The line farthest along the spacecraft path will be given the highest scan line number. This counter is reset after every second sweep.

Figure 3.3-13. Scan Line Identification (SLID) Format

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Table 3.3-10. Support Data Elements

Image Line Supporting Data Word	7 Bit Data Word*	Description
1-4	1 1 1 1 1 1 1	"1" fill bits
5	$0\ X_{11}X_{10}X_9\ X_8X_7X_6$	Original Line Length: X_{11} through X_0 represents the actual number of pixels in the original geometrically uncorrected image scan line.
6	$0\ X_5X_4X_3X_2X_1X_0$	
7	0 X X X X X X	Quality Code (See Figure 3.3-14)
8	$0\ X_1X_2X_3X_4X_5X_6$	Nominal Cal. Indicator: Contains a 1 bit for each Calibration Wedge substitution; example: 000100 indicates that sample #4 was replaced by a nominal value.
9	0 X X X X X X (CWV #1)	Selected Cal. Wedge Values (CWVs) Six binary numbers; one for each Calibration Wedge sample. Binary Values ranging from 0 to $63)_{10}$.
10	0 X X X X X X (CWV #2)	
11	0 X X X X X X (CWV #3)	
12	0 X X X X X X (CWV #4)	
13	0 X X X X X X (CWV #5)	
14	0 X X X X X X (CWV #6)	
15	0 0 0 0 0 0 X	Time Code Indicator: Contains a 1 bit if time code in SLID was calculated (i.e., was not obtained from video data stream)
16 - 20	0 0 0 0 0 0 0	Unused. "0" fill bits
21	$0\ 0\ 0\ X_{15}X_{14}X_{13}X_{12}$	Cal. Wedge Gain Value: X_{15} through X_0 represent the 16-bit binary number applied in the radiometric correction process. Each value has a fixed binary point between positions X_{10} and X_9.
22	$0\ 0\ 0\ X_{11}X_{10}X_9X_8$	
23	$0\ 0\ 0\ X_7X_6X_5X_4$	
24	$0\ 0\ 0\ X_3X_2X_1X_0$	
25	$0\ 0\ 0\ X_{15}X_{14}X_{13}X_{12}$	Cal. Wedge Bias Value: X_{15} through X_0 represent the 16-bit binary number ** applied in the radiometric correction process. Each value has a fixed binary point between positions X_2 and X_1.
26	$0\ 0\ 0\ X_{11}X_{10}X_9X_8$	
27	$0\ 0\ 0\ X_7X_6X_5X_4$	
28	$0\ 0\ 0\ X_3X_2X_1X_0$	
29-32		Histogram Gain Value: Same format as Cal. Wedge Gain Value
33-36		Histogram Bias Value: Same format as Cal. Wedge Bias Value

*Left most bit of each data word is a "0" fill bit
**Negative numbers (bit 15 = 1) are represented in two's complement form (of the integer and fraction field together).

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calibration options is given in Data Format Control Book, Volume VI: Products (reference paragraph 2.2.b). The calibration wedge option was utilized by all previous Landsats. The multiplicative and additive constants which are also used in the calibration process are given in bytes 3001-3048 in the second ancillary major frame.

It should be pointed out that because of computational roundoffs and occational dual entries in the decompresion tables the radiometric calibration process is not uniquely reversible.

A fixed number of fill pixels (with a value of $0)_{10}$) are inserted in each major frame in front of the image pixels. The fill count is different for each band:

Band 1	75 Fill Pixels
Band 2	73 Fill Pixels
Band 3	71 Fill Pixels
Band 4	69 Fill Pixels

The actual number of image pixels in a scan line is specified in the support data. Following the image data more fill pixels are entered to complete the major frame. The first eight fill pixels contain the end of line code (0000 0000 7F7F 7F7F HEX), while the remainder have a value of $0)_{10}$.

The trailing 252 bits of support data in the last image minor frame are composed of 36 seven-bit words containing information associated with each image scan line. These supporting data words are described in Table 3.3-10. The third data word gives a quality code for each image scan line. The possible quality codes

SCAN LINE QUALITY CODE	OCTAL VALUE*	BINARY REPRESENTATION
Q_0 - Good quality	000	0 000 000
Q_1 - Not used in Landsat-D		
Q_2 - Filled line on input	007	0 000 111
Q_3 - Filled line on output	070	$0\ \underbrace{\underline{111}}_{W_1}\ \underbrace{\underline{000}}_{W_2}$
*Left most bit of the seven-bit scan line quality word is a "0" fill bit as shown.		

To properly detect and interpret a quality code in the presence of a one-bit error situation, the following rule is applied:

> If within either W_1 or W_2 there are not three like bits, then the bit value of the majority bits within each three-bit data word is applied to reverse the binary value of the minority bit.

Figure 3.3-14. Illustrations of Quality Codes

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calibration options is given in Data Format Control Book, Volume VI: Products (reference paragraph 2.2.b). The calibration wedge option was utilized by all previous Landsats. The multiplicative and additive constants which are also used in the calibration process are given in bytes 3001-3048 in the second ancillary major frame.

It should be pointed out that because of computational roundoffs and occasional dual entries in the decompression tables the radiometric calibration process is not uniquely reversible.

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The trailing 252 bits of support data in the last image minor frame are composed of 36 seven-bit words containing information associated with each image scan line. These supporting data words are described in Table 3.3-10. The third data word gives a quality code for each image scan line. The possible quality codes

are illustrated in Figure 3.3-14. (Note: Although quality code Q_1 was used for previous Landsats, the processing of Landsat-D and D Prime data is handled in a fashion that does not allow a code similar to Q_1 to be assessed. However, to maintain the previous format, space is still reserved in the trailer data for a quality code summary count for Q_1.)

A quality condition of "good quality" - Q_0 is assessed when no faults are known. A quality condition of "filled line on input" - Q_2, is assessed when the output line was synthetically filled during the data input process, e.g., due to a condition such as "sync loss". A quality condition of "filled line on output" - Q_3 is assessed when the output line is synthetically generated during the data output process. In both these cases the usual result is to repeat the last line which received an assessment of Q_0.

The quality code hierarchy is ordered from most severe (Q_3) to least severe (Q_0). When more than one quality assessment affects the output line, the most severe assessment is assigned to the output line, i.e., Q_3 is assigned when both Q_2 and Q_3 occur.

3.3.7 TRAILER DATA

The trailer data provides counts that can be used for quality control purposes and thus gives a measure of the quality of the image data. An example of a major frame of trailer data is shown in Figure 3.3-15. The data elements that comprise the trailer data are provided in Table 3.3-11.

3232 bits

48 bits | (3184 bits) (398 bytes)

Minor Frame	32 bits	8 bits	8 bits			
0	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	398 bytes of trailer data* Bytes 1 through 398		
1	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	398 bytes of trailer data* Bytes 399 through 796		
2	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	398 bytes of trailer data* Bytes 797 through 1194		
3	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	66 bytes of trailer data* Bytes 1195 through 1260	4 Bytes of CHECKSUM	328 Bytes of Zero Fill
4	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Zero Fill		
5	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Zero Fill		
6	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Zero Fill		
7	SYNC Pattern	Minor Frame Count	Minor Frame Type Code	Zero Fill		

*Byte allocations are described in Table 3.3-11.

Figure 3.3-15. One Major Frame of Trailer

Table 3.3-11. Trailer Data Elements

BYTES	DATA	
1	$\boxed{XXX}$	Flag indicating last scene (each image) in a data interval: $000)_8$ = No $377)_8$ = Yes
2	$\boxed{000}$	Flag indicating last scene (each image) on this reel of tape; not used, always 0
3	$\boxed{000}$	Zero Fill (not used)
4	$\boxed{XXX}$	Geometric Modeling Flag: $000)_8$ = Precision Fit with Control Points $377)_8$ = Systematic Fit
5-148		Inverse state covariance matrix. The inverse state covariance matrix is a 6 by 6 matrix containing statistical information about the 6 state variables; along track, across track, yaw, altitude, along track rate and across track rate errors. This will provide a measure of the quality of the geometric correction process. The elements of the matrix are presented in the following order: Row 1, Column 1 Row 1, Column 2 Row 1, Column 3 . . . Row 1, Column 6 Row 2, Column 1 . . . Row 2, Column 6 . . . Row 6, Column 6 Each value is in the floating point format.
148-153		State vector components modeled. One byte is reserved indicating whether each of the six state vector components was modeled. An ASCII 'Y' indicates the component was modeled, and ASCII 'N' indicates it was not. The components will be in the following order: Along track error Across track error Yaw error

Table 3.3-11. Trailer Data Elements (cont'd)

BYTES	DATA	
		Altitude error Along track rate error Across track rate error
154-844		Zero Fill
845-860		Quality Code Summary Counts for the image (4counts, 4 bytes per count). Counts are in the Fixed Point Binary Format discussed in paragraph 3.2.3.4.1.
845-848	000 000 XXX XXX	Summary Count of Q_0 values. First byte = $000)_8$, octal value of Q_0; second byte is not used; third and fourth bytes contain the total number of scan lines with this quality in the current image.
849 - 852	077 000 XXX XXX	Summary Count of Q_1 values First byte = $077)_8$, octal value of Q_1; second byte is not used; third and fourth bytes contain the total number of scan lines with this quality in the current image
853 - 856	007 000 XXX XXX	Summary Count of Q_2 values First byte = $007)_8$, octal value of Q_3; second byte is not used; third and fourth bytes contain the total number of scan lines with this quality in the current image.
857 - 860	070 000 XXX XXX	Summary Count of Q_3 values First byte = $070)_8$, octal value of Q_3; second byte is not used; third and fourth bytes contain the total number of scan lines with this quality in the current image.
861 - 864	F 000 XXX XXX	Line Quality Map Word Count F = $377)_8$ indicates that a quality map for entire image follows (starting in byte 865) or F = $366)_8$ indicating that a quality map for a partial image follows (starting in byte 865). Second byte is not used. XXXXXX = line quality map word summary count "N" (binary). The maximum value of "N" is $99)_{10}$. The line quality map contains a 4-byte entry for each group of consecutive scan lines that have the same quality assessment. "N" gives the number of these entries.

Table 3.3-11. Trailer Data Elements (cont'd)

BYTES	DATA	
865 to (864 +4N)		First "Line Quality Map Word" where: Q = Octal value of quality word Q_i ($(Q_0 = 000)_8$, $Q_1 = 077)_8$, $Q_2 = 007)_8$, $Q_3 = 070)_8$).
865–868	Q 000 / XXX XXX	Second byte is zero filled. XXXXXX= count of the number of consecutive image scan lines with quality code Q_i (binary)
869–872	Q 000 / XXX XXX	Second "Line Quality Map Word"
873–1256		3rd - 98th "Line Quality Map Words"
1257–1260	Q 000 / XXX XXX	99th "Line Quality Map Word" All unused Line Quality Map Words are zero filled.
1261–1264	XXX XXX / XXX XXX	CHECKSUM value for Trailer Data
1265–1592	000 000	Zero Fill (not used)

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A significant difference from tapes produced for previous Landsats is that copy tapes will not contain parity count information in minor frame seven (7) of the trailer major frame. Copy tapes are identical to the original in every aspect.

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SECTION 4

ABBREVIATIONS, ACRONYMS, SYMBOLS AND TERMS

Band	A collection of pixels representing a spectral portion of a scene
BIL	Band Interleaved by Line data format
BSQ	Band Sequential data format
Bit	The smallest element of binary, computer-intelligible data
Byte	A unit of data consisting of eight bits
CCT	Computer Compatible Tape
CP	Control Point
CWV	Calibration Wedge Values
Detector	A compouent of a sensor that is able to sense incident energy in a region of the electromagnetic spectrum
ECC	Error Correction Code
EDC	EROS Data Center
EDIPS	EDC Digital Image Processing System
EROS	Earth Resources Observation System
GCP	Geodetic Control Point
GHIT	Goddard HDT Inventory Tape
GMT	Greenwich Mean Time
GPS	Global Positioning System
GSFC	Goddard Space Flight Center

GSTDN	Ground Segment Tracking Data Network
HDT	High Density Digital Tape
HDT-AM	High Density Tape containing partially processed MSS data
HEX	Hexadecimal, base 16 notation
HRS	Horizontal Resampling
Interval	Set of contiguous scan line imagery comprised of one or more scenes
IGF	Image Generation Facility
IRIG-A	Inter-range Instrumentation Group standard time, format A
Landsat	Land Satellite (formerly ERTS - Earth Resources Technology Satellite)
LSB	Least Significant Bit
MFTC	Minor Frame Type Code
MIPS	MSS Image Processing Subsystem
MSB	Most Significant Bit
Pixel	One image detector sample
PS	Polar Stereographic Projection
Right Justified	Technique of positioning data so that the least significant bit appears in the rightmost position
S/C	Spacecraft
Scan Line	The data produced by one cross track motion of an active detector (a full scene width)
Scene	One or more spectral bands of data representing a 185km X 170km ground area

Sensor	An imaging instrument (a sensor may consist of one or more detectors)
SOM	Space Oblique Mercator Projection
Swath	The terrestrial strip viewed by the spacecraft
Sweep	One back and forth cycle of mirror movement
TDRSS	Tracking and Data Relay Satellite System
Tick Marks	Positional marks placed on imager to enable a location grid coordinate system to be constructed
TM	Thematic Mapper
UTM	Universal Transverse Mercator Projection
VRS	Vertical Resampling
WRS	World Reference System